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CONTENTS FOR APRIL 1944

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EDITORIAL

Trading Fighters for Food

FOLLOWING a brief period in which the "unit" requirements for deferment of farm workers were substantially increased, news reports at time of this writing indicate that the whole unit system is to be thrown out the window, draft boards directed to use their own discretion, but required to produce their quotas. All this is of peculiar interest to members of the American Society of Agricultural Engineers who know that, at the Society's fall meeting in 1942, where sundry government men were in attendance, a complete working plan was offered for grading farms and farmers according to their effectiveness in production. Although the data embodied in that report are said to have been helpful in a backdoor sort of way, the vital principle of production efficiency appears to have been officially ignored.

Just as the Chinese and Russians pursued the policy of trading space for time, so do we trade fighters for food by deferment of farm workers. Realistic regard for that fact reveals the futility of a unit system which counted only numbers of acres and animals and ignored their yield. On the basis of 1943 state-wide corn yields and the presently discarded unit system, one deferment in Iowa would buy nearly 5,000 bu of corn. To get the same amount of corn in 14 other states would take more than three deferments, and in six of them more than four deferments. Consideration of individual farm yields would reveal far wider, even fantastic ratios.

Allowances for animal units were equally inequitable, not to say iniquitous. Not only all men but all cows were created equal in the eyes of government. Consumers paid for their dole of butter in points per pound, but the armed services paid in men per cow, no matter whether she produced 500 pounds or 75 pounds. Thus blessed by the government, the keeping of a cull cow to keep a son or a hired man on the job can hardly be condemned, though it amounted to a waste of feed.

Though the formula for units may be gone, the facts remain and they should be heeded if there is a real desire to administer selective service with an eye to production rather than politics. Within the domain of each draft board it will be possible now to measure the milk instead of counting the cows, to weigh the wagon instead of surveying the cornfield. Our observation of local agencies is that they are much more accurate in arriving at an objective through direct knowledge and common sense than is the application of remote-control formulas.

But between one local board and another, among states and regions, no such common-sense application of the productive principle seems thus far to be provided or even permissible. We still shall sacrifice three soldiers in 14 states when one would be sufficient in Iowa, or we shall get one bushel of corn where we could just as well get three. There is not less but more need for thinking in terms of production by those in high places who dictate man power policies.

No one can speak with more authority about productive capacity than the agricultural engineer. Few can speak and command more respect for their sincerity and sound judgment. We deem it proper and patriotic for agricultural engineers to exert all their influence on this or any question whereon they can speak with authority.

At the risk of wandering a bit from our own field, we might add a suggestion to other engineers. They, too, in their respective industries may be able to create criteria whereby individual production can be made the index to deferment. A shipyard worker, to cite a single random example, remarked that his crew of 18 could get more done if reduced to 11, thereby getting excess personnel out of the way. In such cases, just as in agriculture, suitable production grading of individuals would show where man power could best be spared.

Synthesized Spraying

AT A meeting of the American Society of Agricultural Engineers some years ago, at which the subject of farm management was being given special emphasis, one Society member suggested that agricultural engineers should not be content with analysis of agricultural matters but should do some synthesis; that is, think more of the farm as an integrated unit and put together a plan for its operation rather than deal with isolated elements. Similar thinking now inspires another member to offer a proposal with respect to spraying.

In every phase of agriculture, both plant and animal, the pest problem becomes more acute as production becomes more intensive and efficient. Not only are the comparative immunities of scrub and mongrel lost, but also the effectiveness of time and isolation as controls. Apples, peaches, grapes, melons, potatoes, citrus crops and many others are grown with commercial quality and on a commercial scale only by continuous warfare on insects and disease. Indeed, says this member, decadence of the home orchard, vineyard and truck patch is mainly a retreat from these same enemies.

In animal and poultry husbandry the hazards and handicaps of diseases and parasites have called forth the sundry systems of sanitation, most of them involving disinfection of buildings and equipment. Conservation farming with its emphasis on small grains and grasses brings its problems of noxious weeds and the possibility of their control by chemical sprays. Field crops also are increasingly limited by wilts, blights and rusts; e. g., the difficulties brought by alfalfa yellows. As has been mentioned here before, the field for stubble-mulch tillage (apart from its other limitations) is sternly bounded by the corn borer.

To meet most of these problems we already have effective equipment for spraying, dusting or fumigating. As a rule this present equipment is economical and efficient in labor usage only where the unit can be of rather large capacity and cost, and used for a considerable volume of work within its own range, usually rather narrow, of adaptation. Thus the large or specialized farm or plantation is well served, but the diversified place of medium or small size is not.

What our member envisions is a single outfit, probably a spray rig, of sufficient power and convenience to do all of these varied jobs effectively and economically; not necessarily a cheap outfit, but one of such varied usefulness that its overhead costs when distributed among many operations would not be prohibitive for any. He has hopes that the market would be big enough to permit the economies of mass manufacture of a pretty well standardized model.

Before industrial genius addresses itself to the job of design, there is a research job to define the functional requirements of all these varied operations, and to reconcile them into a single set of reasonable specifications. It looks like a job for agricultural engineers in cooperation with entomologists, pathologists, agronomists and husbandmen. There is precedent and promise for such a project in the comparable activity on fertilizer application.

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Farm Electric Equipment for Postwar Needs

By Geo. W. Kable
FELLOW A.S.A.E.

AFTER the war there will probably be in excess of 2.6 million farms in the United States (about 43 per cent) having central service station service. In addition there will be applications on file in utility and REA offices from hundreds of thousands of additional farmers wanting service. Many of these will have unfilled desires for electrical equipment which have been abetted by the restrictions and labor shortages of wartime. They are likely to be in better financial condition to acquire equipment than they have been for many years.

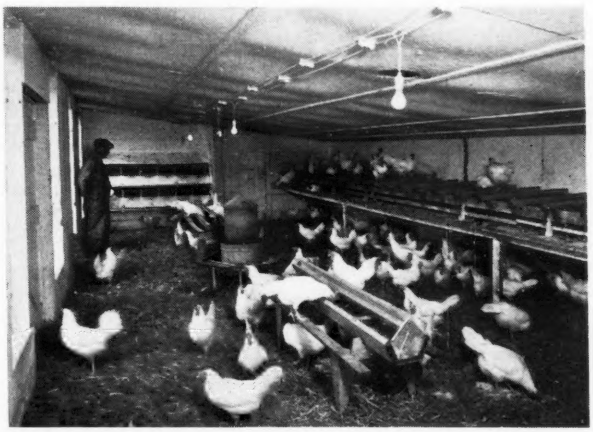
With our rapid expansion of rural distribution facilities and widespread interest in electricity for the farmer, we are still far from even a reasonable use of electricity in farm productive enterprises. Let me cite the results of a survey reported last year which substantiates this statement. The survey was made in Marion County, Oregon. It was conducted jointly by the Bonneville Power Administration, the Portland General Electric Company, and the extension service of Oregon State College. Marion County is a rich dairy, poultry and fruit section in a prosperous general farming area west of the Cascades. It has been served by the Portland General Electric Company for many years. It is what one might call a fairly typical, well-electrified county. The average annual farm consumption was found to be 1504 kw-hr per year. There was a high saturation of appliances in the home. In farm productive enterprises, however, there were only two appliances with a saturation above 7 per cent. These were electric fence controllers with a saturation of 29 per cent, and electric brooders with 15 per cent. There was not more than one farm in fourteen that had any other one type of productive equipment. It is also significant to note that while the average consumption was 1504 kw-hr per year, 5 per cent of the farms used 9886 kw-hr and 95 per cent used only 1062 kw-hr. In other words, the average farm was not a large user of electricity. There was only one large user in twenty. Any way you look at it, these farms are only 20 per cent sold on the use of electricity in production. You can select well-electrified counties in almost any state and obtain very similar figures on the existing status.

In order to find out some things about electric equipment directly from farmers, "Electricity on the Farm" is conducting a "suggestion forum" in which one of the questions asked is "What is wrong with available equipment that has kept farmers from using it?" A few have said that prices were too high and that service on equipment was discouraging, but the majority said they did not know where to buy the equipment or that they could not go in and see the thing they were interested in buying.

In a discussion recently with Roy Robertson of East Tennessee Power & Light Company, he mentioned offhand about twenty items of equipment which were not in stock or on display in normal times in the seven counties they serve. It included such things as motors, blowers for hay driers, soil heating cable, utensil sterilizers, complete stocks of house wiring materials, hay hoists, irrigation equipment. And his territory includes three industrial cities of 25,000 population or more.

This paper was presented at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1943, as a contribution of the Rural Electric Division.

GEO. W. KABLE is editor, Electricity on the Farm.



What I have to say about equipment and what you do about it in your research laboratories and draughting rooms will be of little value if a bottleneck continues to exist through which our design efforts cannot pass beyond a pigeonhole or a local plant to the farm users of electricity generally. We should realize this. I have ideas for a solution, but they do not belong in this paper.

An Appraisal of Farm Needs. At the end of the war it is reasonable to expect that a relatively large number of men will return to the farm from the military service and from war plants, many of whom will be trained in modern methods of production and in doing things the machine way. They will have had experience in the use of electrical equipment, welders and machine tools. The population on farms will increase, and the number of farms will very likely increase due both to a general return to the land and to a government rehabilitation program.

For a year or two following the war there is likely to be a good demand for farm products for export. The ensuing years will be questionable for farmers. If our program of making over the agriculture of the world by supplying American machines, American engineers and American methods is at all successful, we can hardly expect to retain our foreign market or to have a very remunerative home demand for farm products as we now know them.

These facts and possibilities must be born in mind when thinking of farm electric equipment for the future. It takes time to develop equipment and it is unlikely that much newly developed equipment will be ready for distribution during the flush period immediately following the war.

Farming will continue to be a way of life and a business. So long as demand and prices remain high, the business side will predominate. When profits become small, the mode of living must furnish the major compensation. Electricity has and will continue to add much to farming as a way of life. On the business side of farming, use of electricity is just developing.

Equipment for Living. Equipment for living is of two types. Lighting, household appliances and conveniences, and running water are of the first type. A good job of design and of manufacture and distribution of this equipment has been done. Water system manufacturers are pretty much on their toes, except that water systems and plumbing should be sold as a unit. Small appliances, refrigerators, ranges and water heaters might serve the farm a little better if designed especially for it, particularly as to size, but I personally believe the advantage would not offset the disadvantage of higher price made necessary by lower volume of production. Farm women are not much different from urban women in their desires regarding color and finish. The advantage of mass production is so great

that I seriously question the desirability of farm models. Even with refrigerators, it may be cheaper to buy two 7 cu ft boxes than one 14 cu ft box. A little study might show that they are also cheaper to operate and that most farms have plenty of space for them and in spots where the two boxes would save steps. On this basis I see no particular need for agricultural engineers to spend their time on the design of generally used household equipment.

The other type of equipment for living is production equipment. The relationship is psychological. Some people just start living happily when their production plant is well equipped, efficient and sanitary. Their pride in production provides the zest for living.

Equipment for Business. Equipment for the business of farming implies that it should be money making, labor saving or product improving equipment. In the postwar period it may have to be more than that. The problem of labor shortage will not be so acute then and may even be reversed. It will probably be necessary to find employment for more workers on the farm. This suggests an equipment field which has not been very thoroughly explored or investigated. Considerable has been said about processing or preprocessing of farm products right on the farm. This is still pretty much in the speculation stage. It offers a field for research which is not overcrowded. Men with skills will be available on farms. The products will be at hand.

Similarly the establishment of small manufacturing enterprises on farms offers possibilities. The time is almost certain to come when some sort of supplemental employment on the farm will be desirable. Anyone who has a solution, with the equipment needed, will be a benefactor. It is not too soon now for agricultural engineers and farmers to be sitting with city planning groups to consider this problem along with other postwar employment plans. The 100-man war plant may be of much less importance to the small city than the 1000-man basic farm industry that surrounds and supports it.

It is not easy to name new items of equipment which will be needed for postwar agriculture. Many people are pondering what will be in demand and what can be made in the factories now devoted to war production. I can mention a few things that are not new but that are not now available. One is a small-capacity milk pasteurizer for the small town and rural dairy—not primarily as a current-consuming device but as a safeguard to public health. The incidence of undulant fever and some other milk-born diseases is greatest in the areas without pasteurization. The design of the pasteurizer is not too difficult. The hitch comes in the requirements of the public health bodies for recording instruments and for supervision and records which make pasteurization impractical for the small producer.

SOME EQUIPMENT NEEDS FOR POSTWAR PRODUCTION

Only one company in the United States has made a simple, inexpensive, single-lever controlled hoist which I consider practical as a labor-saving hay hoist to be controlled from a load of hay. The company had no distribution. It is now out of business.

There is need for a reasonably priced blower unit designed especially for mow hay driers. The mow hay finisher has excellent prospects.

A packaged electric ventilating unit has been suggested by Ralph J. Bugbee, a member of this society from Vermont.

Some of the most laborious tasks on the farm are the handling of hay in feeding and the cleaning of barns. There is no completely satisfactory equipment for doing these jobs.

A suggestion has come to us from a farmer for a cream separator without a crank and of kitchen-mixer design for the one to three-cow farmer.

Food freezers are of first importance, but there seems to be enough designers working on them.

It would take a supergenius to think of many practical applications of electricity on the farm that someone else has not thought of. It does not take much originality to think of equipment which should be used more widely on farms, if the design and cost were right, if farmers knew about it, and if there was effective distribution.

Requirements of Farm Electric Equipment. Realizing that what I have to say may be trite to some of you, I would nevertheless like to put on record some facts about the use of farm equipment that should be taken into account in its design.

Practically all farm electric service is single-phase service. Because of the relatively great distances between farms, individual transformers are usually necessary and the cost to serve, and often the service charge or rate, is high if the demand is high. In the design of equipment it is obviously desirable to keep the demand low and the load factor and diversity high.

The annual use periods of much farm equipment is notoriously low. A combine or hay hoist or silo filler may be used for only five or ten days in a year, and a hay drier possibly a maximum of sixty days. Generally the investment cost per day of use is high. This must be reckoned with in design. An irrigation pump in California where it may be used quite continuously for seven months in the year should be an efficient piece of equipment, while in New Jersey, where it may be used for seven days in the year, efficiency is relatively unimportant in comparison with first cost.

Ruggedness and reliability of operation is important in such equipment as water systems, incubators, brooders, milkers, laying house lights. The farmer has no plant engineer to call on when something goes wrong. He is also dealing with life processes which cannot wait on repairmen. If the brooder element burns out, the chicks chill and die or pile up and smother. If the milker stops, the cows must be milked by hand — *now*. If the hen house lights fail, the birds may go into a moult and be off production for the season. If the freezer compressor stops, the year's food supply is spoiled. The farmer is no expert electrician or mechanic, but his equipment to be satisfactory must be such that he can care for it and keep it running.

Farmers are accustomed to large power units. They grind a week's feed with the tractor in three hours; they jam the year's ensilage through the cutter in two days. Either large power units must be provided or small ones must be semiautomatic and have other advantages to offset bigness.

ELECTRICITY IS CONCENTRATED POWER

What We Have to Deal With. In the past most of our effort to provide electrical farm equipment has been in the substitution of electricity for some other source of light or power. That was a logical development. Now, after almost twenty years of substituting we should perhaps be giving more thought to the peculiarities of electricity which enables us to do things with it we could not do without it.

Electricity is a concentrated power. We can easily carry five horsepower through a knothole. It can be controlled by thermostats, pressure and time switches, by intensity of light or by simple weights, float switches or push buttons in remote places. Heat may be applied in mild or intense quantities in confined or large spaces, by radiation or convection, and with no danger from flame or explosion. The use of lamps in production as typified by lighting laying hens, heating small dehydrators, pig brooders and hotbeds and in catching insects has prospects for great expansion. The possibilities of electronics in agriculture have scarcely been considered.

There is another condition with which we must deal in connection with postwar equipment. Many farms have been wired for periods in excess of ten years. Hardly any of these, and few of the farms which have been connected since, have an adequate job of wiring. Many of the entrance services were placed in houses with successive extensions from house to barn to milk house to hen house and so on. Additional equipment on these extensions will mean low voltages which will preclude satisfactory operation of the equipment and result in loss of current in heat in the wires, with serious fire hazards. Any attempt to increase productive uses of electric equipment must almost certainly include plans for major rewiring of a large percentage of farms. This is a different problem than that of rewiring city homes. With increased use of electricity in barns and other farm buildings we can expect some rather disturbing losses of livestock and property unless more attention is given to grounding of wiring, metal stanchions and equipment, and the employment of insulated wiring systems. Just grounding is not enough. Experience has shown that to be effective a ground must be less resistant to the passage of stray currents than a cow's body with its neck or nose in contact with live metal and its hind feet on a urine-soaked barn floor. Since equipment cannot be expected to function well at abnormally low voltage and burdened with costs of heating long stretches of small wire, the wiring becomes very much a part of the equipment problem.

The Underwriter's code, although *(Continued on page 124)*

Electricity for Daily Farm Chores

By Grover C. Neff

MEMBER A.S.A.E.

FARMERS generally are now using electric service for only a fraction of the farm work for which it should be used. While considerable progress has been made in the last twenty years in applying electric service to agriculture, we have made only a good start. Electricity has not been applied to farm work as it has to factory work. The big job ahead is to do that which is necessary to bring about the use of electricity in agriculture for every possible job to which it can be advantageously adapted.

A few years ago a group of men representing English trade unions came to this country to study conditions here, to learn why living conditions in America were on a so much higher plane than in England, why 80 per cent of the automobiles in the world were used in the United States, why three-fourths of the telephones were in this country, why American workmen received two or three times as much pay per day as those in England. This particular group of Englishmen reached the conclusion stated in the British Electrical review, one of the leading industrial organs published in England, as follows:

"The highest standard of living of all classes in the United States is evident to the most casual observer, and the recent delegation of British trade unions saw that the reason lay largely in the extensive use of machinery and labor-saving devices and the initiative displayed in American business organizations.

"The rapid advance of the light and power industry in the United States is the envy of every foreign country, and the benefit of such a development is found in the solution of labor problems. If human beings are made the controllers of power instead of the generators, their earning power is so much increased as to make it possible to pay them not only a living wage, but a cultural wage."

It is interesting to note that these trade union representatives credited prosperity in this country largely to the extensive use of power machinery and labor-saving devices and gave a great deal of credit to the electric light and power industry.

Considerable progress has been made in replacing hand work on the farm with machinery, but unless and until farm work becomes mechanized to the same degree as factory work, farmers will have difficulty in competing with factory operators on an equal basis. There is no question but that the farm badly trails the factory in the extent to which electric service is used; a much larger percentage of work is done by hand power on the farm than in the factory.

It is the job of those interested in rural electrification to see that this picture is changed, that so far as possible electricity is applied to farm operations to the same degree that it is in the factory. If this is done, we may find the answer to a lot of present troublesome farm problems. In the factory every operation is studied to see if the work can be done more efficiently, cheaper, and more rapidly by the use of a machine driven by electric power. Great care is taken to get the factory properly arranged so that work flows through it with a minimum of effort and at the lowest cost. Time studies are made, resulting in a very high output per man. The men can be paid a high wage and the cost of the product still remain low.

I do not know to what extent this has been done on farms, but it must be done if the farm is to keep pace with the factory. We must do the things necessary to increase the output per farm operator; then the farm operator can receive more profit and yet the price of the product sold can be kept within reasonable limits.

More progress has been made in mechanizing field work and doing the bigger jobs on the farm than in mechanizing the jobs in the barn and other farm buildings in which daily chores are carried on. An appreciable per cent of the farmer's day is spent doing daily chores. In Wisconsin where nearly every farmer milks a dozen or more cows, daily chores take up an important part of his day. Even in other sections where there is less dairying, the daily chores must be one of the big items in a day's work.

It seems to me that, if we would all concentrate on applying electric service efficiently and fully to all tasks connected with daily chores, we would be attacking the problem at a point where we would make the most rapid progress and give the farmer the biggest benefits. The objective should be to do things around the farm buildings with electric power which will reduce the amount of hand labor needed, so that fewer people will be required to carry on the many operations.

For example, on many farms a great deal of hard manual labor is used in carrying feed from one building to another. You have seen a farmer carry corn from the corncrib to his feed grinder in another building; or take it to town for grinding, bring it back, and then carry it from wherever it is stored to some other building to feed to livestock. While that system works, it requires about three or four times as much manual labor as should be required.

You have also been on farms where the grain is elevated by power-driven elevators to bins high in the barn. The feed grinder is located below the storage bins but above the feeding room, and the grain flows by gravity from the storage bins to the feed grinder and from there to the feed bins which are located adjacent to the feeding floor. The difference between using elevators and feed grinders properly placed and carrying corn from the corncrib to where it is to be ground and then to where it is to be fed is the thing I am talking about. Many man-hours each month can be saved in this operation by proper arrangement, proper buildings, and proper equipment.

I am of the opinion that the feed grinder I have just referred to should be small in size and cost, and should operate a number of hours each day thereby giving the machine a proper load factor.

A feed grinder driven by a tractor must necessarily be quite large so that the grinding job can be completed in a relatively short time, because an attendant is required to watch the tractor and feed grinder while in operation. On the other hand, a small grinder powered by electricity, and with automatic features, does not require an attendant. If something goes wrong, a fuse is blown, the machine stops, and no harm is done. However, the people who work on this problem must constantly keep in mind that a new line of machinery will have to be developed if full advantage of electric power is to be obtained.

There are dozens of jobs done on the average farm today that require manual power and hard work which will have to be replaced with power-driven equipment properly designed and built to meet the conditions, if we are to take full advantage of electric power on the farm. The big job of rural electrification during the next decade, therefore, will be to develop a full line of electrically driven machinery for agriculture and also to carry on an educational program which will help farmers arrange their buildings properly when building or rebuilding them, and in so doing materially reduce the amount of manual labor required for each farm chore operation.

The development and efficient use of electrically driven machinery has been a necessary and important factor in the relatively high income received by the factory worker. If we make a comparable use of electric power in farm work, we will bring about increased production and higher income per farm operator. Our job is to develop the necessary machines and see that they are properly installed and efficiently used. If we do this, we will lend a big hand to the solving of many problems that are now troubling farmers.

* * *

When it is realized that only a few farms are served for each mile of rural distribution lines, it can be understood that many hundreds of millions of dollars have been spent to pay for nearly one million miles of farm lines. It is indeed a tremendous development that has taken place largely during the past twenty years. The picture we see of rural electrification is a fast-moving one. I am convinced it will continue to show rapid development.

From an address before the Rural Electric Division at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1943.

GROVER C. NEFF is president, Wisconsin Power and Light Co.

The Logistics of Wartime Food Production

By S. P. Lyle
FELLOW A.S.A.E.

THE farmer is on the food front and needs workers and supplies. In its military definition "logistics" involves transportation and supply, the field arrangements for campaigning. Agricultural engineering renders a much similar service to farmers in their food campaign. This type of service is especially needed during the war. Our purpose in this service should be made effective, and we should aid others also engaged in logistic services to farmers to make their work effective. For example, one of the basic requirements for food production is labor. The War Food Administration is responsible for the farm labor program in which the Office of Labor handles the interstate and foreign farm labor supply and the Extension Service the intra-state farm labor procurement and placement. In the seven months from the enactment of the law establishing the 1943 farm labor supply program to the end of November a total of 3,827,718 workers were placed on farms, of whom 3,660,193 were employed for seasonal work and 167,525 for year-round service. Of the total number of placements 57 per cent were men, 19 per cent women, and 24 per cent youth.

These figures represent a very significant service to the farm front, as a comparison with total figures indicates. The U. S. Department of Commerce reports ("Survey of Current Business", December, 1943) the total number of farm laborers in July, 1943, as 12.1 million; in September, 11.3 million, and in October, 10.7 million, while the total civilian labor force was estimated at 55.5, 53.3, and 52.6 million for the same months. In brief, in a most critical labor situation the farm labor front was supplied through a vigorous farm labor supply program.

Other critical supply services to farmers have "come through" also as the production record proves. Among the supplies were seeds, fertilizers, insecticides, fungicides and others including household supplies. Agricultural engineers are especially concerned with the adequacy of farm power, machinery, buildings and equipment, fences, field and highway transportation, and devices and practices for assuring maximum production with safety. They share this concern with others and extend their aid beyond the production tasks of the farm to the equally essential work of the homemaker.

Agricultural engineering services are of tremendous importance in war food production. They constitute not only indispensable links in agricultural service to the nation, but also pair with and complement almost every other scientific service to modern farming.

This statement is no boast, for we are only acknowledging the magnitude and extent of agricultural engineering responsibility for serving the farm front. It is fortunate for agricultural engineers that they do not stand alone in this responsibility, and it is reassuring to know also that engineering services are durable, that services performed ten, twenty and even more years ago are actively utilized in food production in 1944. We must keep these on the job for some of them, in building materials and construction, for example, are temporarily practically irreplaceable.

A fact frequently stated about this war is that it is a war of machinery. Recently I met a high-ranking officer of the Army Air Force on a railway diner, where democracy really flourishes nowadays. He remarked that few people realize the striking power of a modern bomber, and illustrated his point in terms of man power. "There are," he stated, "four 2000-hp engines on the plane, and each horsepower is equivalent to 10 men in power. That makes the 9 or 10 men on the bomber equal to 80,000 men in the war work of putting explosives where they do the right job at the right time."

Farm equipment also saves man power and does its essential work when it is most needed. Machine power is multiple man power, but it is not a magic creation. It is produced by man power from products of man power, and is transported, fueled, serviced, and operated by man power to serve mankind. Machines not only bring the services of civilian workers effectively to the front, but also bring with them the added striking force of the accumulated man power of our magnificent industrial facilities which were ready for conversion to war use. The same facts apply to our agricultural production plant. It is wonderful but not surprising that both the industrial and the agricultural production of this country have been phenominal and have supplied all of our allies with essential additions to their own supplies while our own country is engaged in all-out military armament and action.

Farm buildings, likewise, are multiplied man power. The man-hours of construction labor that went into a barn or a storage building years ago are on the job today as effectively as the day the building was put to first use, if the building has been maintained and adapted to production needs. That is a big part of the engineering job in agriculture as well as in industry. Keep those accumulated man-hours working to win the war.

In these times agricultural engineers, like all other qualified specialists in the sciences serving agriculture, have a responsibility to appraise farm needs and lend their aid to enable farmers to cope with their problems. I know you are doing so and I realize it is trite to recite to you the array of items which you should check, such as the repair of all types and kinds of equipment and buildings which transform agricultural land into productive farms, or the provision of new buildings or machines where they will serve production best, or the utilization of labor and equipment for maximum results, or the conservation of life and property, or the utilization of the full productivity of the land through soil-saving and soil-building practices, or by drainage or irrigation where profitable for war purposes. This subject matter we know, but how resourceful are we in making it useful to the farmer? That is a pertinent logistic problem for us to explore and develop answers during this meeting.

In viewing this problem we recognize that we are only a small professional group representing producers of goods, commercial services, transportation, and scientific, technical and advisory services to farm people. We recognize that the farmers were, generally speaking, well prepared in our field of service at the beginning of the war and that they and their commercial services of supply have done a magnificent job with a minimum use of critical materials. The coordination of this effort has been aided greatly by agricultural engineers in all the different organizations in which they are employed. The war work has brought us closer together and made our efforts more effective, but there is much more to do. Let us meet the tasks of 1944 with greater coordination of effort than ever before. When history appraises this record let it be apparent that the engineering services for war food production were adequate and on time. This is a challenge to our perception, foresight and determination to accomplish this logistic war task.

And now a word about the future seems appropriate. Just as the momentum of peace-time mechanized agriculture carried farmers victoriously into their war programs with virtually no crop setbacks in spite of drastic restrictions in labor and supplies, so will certain effects of wartime agriculture carry over into the time of peace to which we look forward. Here are a few examples. Crop expansion to meet war food goals must be followed by renewed efforts for soil conservation to replenish the reserves of soil fertility upon which some overdraft is now necessary. Rural electrification will again renew its rapid expansion. Rural industries which contribute directly to rural employment, to the use of agricultural products, and to advancement of rural living standards will probably be needed and developed in post-war adjustments. Greater production efficiency to improve quality and lower costs of certain agricultural products, including cotton, apparently will be of greater importance after war markets disappear than ever before. A rural building program is needed to serve the housing needs for all classes and sizes of farms, and the farm building requirements of postwar agricultural production and marketing. This involves credit facilities, and services adapted to a wide variety of building needs. Among other building needs are county agricultural buildings and various recreational centers. *(Continued on page 124)*

This paper was presented at a meeting of the Southeast Section of the American Society of Agricultural Engineers at Atlanta, Georgia, February, 1944.

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Erosion Control on Slopes Steeper than 12 Per Cent

By Earl G. Welch
MEMBER A.S.A.E.

HOW TO control erosion on slopes under 12 per cent is fairly well established for the various sections of the United States. The methods are contour cultivation, strip cropping, terracing, and diversion ditches coupled with proper agronomic practices. But the control of erosion on cultivated land steeper than 12 per cent is much more difficult. The general recommendation for controlling erosion and maintaining soil fertility in areas of rough relief is to keep steeper slopes in pasture or meadow, to reserve land less than 10 to 12 per cent slope for tilled crops in rotation, and to follow a livestock type of farming so that the forage crops produced may be used. Where the proportion of gentle slopes to steep slopes permits a farmer to plant the desired acreage of row crops on gentle slopes and to produce the required forage on permanent pasture and meadow fields, these general recommendations may be applied without difficulty. Where the proportion of gentle slopes to steep slopes is low, farms are small, and cash crops aside from livestock seems essential, the application of the recommendations becomes more complicated.

A typical example of forage-livestock farming under this latter condition is found in the Kentucky area known as the "Hills of the Bluegrass." Here leading farmers follow quite well the practice of using the land for those crops for which it is best suited and they use the agronomic aids that help hold soil in place and maintain its fertility. These farmers feel, however, that they need additional measures for controlling erosion.

It would be unwise to recommend to these farmers new practices which may complicate their farming operations or to formulate for them an entirely new erosion control program without examining conditions in the area to determine if the expressed need for additional erosion control measures arises from a failure to carry out present recommendations or if present recommendations are inadequate. Upon examination the following facts were found:

1. The area is largely composed of steep hills with a slope of 20 to 25 per cent, V-shaped valleys, and narrow ridges. About 12 per cent of the area has a slope of 10 per cent or less.
2. In general farms are too small to provide, from the forage-livestock type of farming, an income sufficient to maintain present living standards.
3. Tobacco is produced as a cash crop to supplement income from such major sources as sheep, cattle, pasture, hay and corn.
4. Only about 10 per cent of the land is annually planted in clean, cultivated crops, such as corn and tobacco. This acreage is about equal to the area with a slope of 10 per cent or less. It must be reduced still further if row crops are to be in rotation and planted on gentle slopes.
5. During the past 50 years in the adjustment of farming operations to physical conditions, corn acreage has declined 65 per cent; hogs, 80 per cent; hay acreage has increased 100 per cent; sheep, 300 per cent; dairy cattle slightly. During this period the population of this area has declined 30 per cent.
6. Although the virgin surface soil of the area, rich in organic matter and one of the most fertile in Kentucky, has been practically removed from the steep slopes by erosion, it is as a whole still quite productive.
7. With sufficient moisture the subsoil produces good pasture and hay but it dries out quickly unless there is plenty of rainfall evenly distributed. Frequently, however, a lack of moisture in the soil limits the amount and quality of pasture and meadow crops. Moreover, from the time of seeding until there is enough grass to protect the soil much sheet erosion and gullying take place on the steep slopes. Clearly the organic matter in the soil cannot be increased materially unless erosion is controlled.
8. Strip cropping on steep slopes has not proven effective in controlling erosion primarily because the heavy subsoil does not absorb water readily and previous erosion permits the concentration of water in small gullies.

To improve conditions in this area leading farmers for many years have believed that an additional measure of erosion control was needed, particularly mechanical structures to divert water from ridge land and steep slopes throughout a rotation. In many instances such as this, soil conservation and improvement programs have been planned for steep slopes without mechanical control measures, but the definite need for them eventually results in their inclusion. It is believed that water channels should be incorporated in a complete program for controlling erosion in the Hills of the Bluegrass and in similar areas of rough relief.

Types of Water Channels. In order to distinguish between various types of water channels for hill land the following definitions and distinguishing features are given:

A *terrace* is a primary soil erosion-control structure consisting of a ridge of earth thrown up across a slope, to retard the flow of water and to conduct it to an outlet protected from erosion. Such a terrace is constructed on slopes not exceeding 12 per cent; it is spaced at vertical or horizontal intervals which vary with the per cent of slope; has a maximum channel grade of 0.5 per cent, and a ridge of such width and side slope as to permit the cultivation of intertilled crops on the terrace.

A *diversion terrace* has the following distinguishing features: It is used on slopes of from 12 to 25 per cent; has a maximum channel grade of 1 to 1½ per cent; uses sod to maintain ridge and channel with a 10-ft buffer strip; has a ridge with a minimum height above the water channel of 1 ft and a channel 2½ ft wide at the bottom; is spaced at regular horizontal intervals which do not vary with the per cent of slope. The horizontal interval is the width of one corn shock row, usually 50 ft, plus a buffer strip 10 ft or more in width above and parallel to the water channel. The variation in width of the buffer strip is made to permit an equal width of tillable area between diversion terraces.

A *diversion ditch* is a water channel constructed across a slope to intercept water from a higher elevation and conduct it to a protected outlet. It is especially designed to care for a particular situation and constructed so as to prevent erosion or silting of the channel. It is used to intercept water from the entire area of a ridge so as to reduce erosion on steeper slopes be-

Leading farmers have for many years used hillside ditches for controlling soil erosion on steep slopes in the bluegrass region of Kentucky

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low or to protect an area of bottom land from damage by runoff from steeper slopes above.

A *hillside ditch* is a drainage channel with a grade of 2 ft to 6 or 8 ft per 100 ft placed at regular horizontal intervals across a slope to prevent gullying. It is constructed with a plow only and therefore is usually not more than a plow furrow in width and one or two plow furrows in depth. It is used only on slopes where the subsoil resists erosion well, such as that found in the Hills of the Bluegrass in the Eden formation.

General Land-Use Policy. The following general principles for properly using ridges and steep slopes include water channels as an erosion control measure with the usual recommendations for vegetative control and soil fertilization.

Cultivate in row crops in a short rotation the *ridges of the hills* from the top to the points where slopes equal 12 per cent grade. Use terracing and contour cultivation to reduce sheet erosion to a minimum, the principal cause of loss of fertility on ridge land. The objective should be to increase the productivity of the ridges as much as possible in order to reduce the need for cultivating steeper slopes in row crops. Greater progress can be made in the improvement of yields on ridges than on steep slopes because of the greater ease of conrolling erosion and the lower per cent of runoff. The control of runoff and erosion by terracing ridges greatly reduces the erosion problem on steeper slopes.

Steep slopes with grades from 12 per cent to approximately 30 per cent should be used primarily for pasture and meadow crops to produce forage for livestock. This end may be achieved by observing the following: Eliminate row-crop cultivation on these slopes; increase the moisture-holding capacity of the soil by adding organic matter; use diversion terraces on steep slopes to aid in controlling erosion while grasses and meadows are being established or re-established and organic content of soil increased; limit these efforts to slopes approximately under 30 per cent, since mowing, an essential to the elimination of weeds and bushes, cannot be practiced on steeper slopes; plant trees in draws and areas in excess of 30 per cent.

Use of Water Channels. Establish and construct *terraces* on terraceable slopes according to generally accepted practices. Terrace the land when it is in sod or meadow so that outlet channels may be left to provide for the removal of terrace water from near the top of the slope to natural outlets. Make terraces as wide as can be done economically with the equipment and power available.

Do not substitute *diversion terrace systems* for terraces on terraceable land. Plan diversion terrace systems so as to permit field equipment to be moved from the foot of slopes to ridges without crossing terraces.

Use *diversion ditches* only below areas from which little silt will originate. These areas may consist of permanent wooded land, permanent pasture or meadow land. Unless the drainage area above the diversion ditch is similar in size to that above other similar diversion ditches of proven carrying capacity, design a diversion ditch to meet the existing conditions. This is strictly an engineering problem. Diversion ditches may be used in connection with strip cropping on long slopes in some sections of the Hills of the Bluegrass area.

Use *hillside ditches* only on land with a subsoil which resists erosion well, on steep slopes planted to row crops, or to control erosion while meadows and pastures are becoming established. They reduce rather than control the erosion which occurs when heavy rains fall on plowed steep slopes. These temporary structures are usually filled with silt by the time the root system of meadow or pasture is well established. They are stepping stones to the construction of terraces or diversion terraces.

Wartime Food Production

(Continued from page 122)

War also has caused us to become acutely conscious of the need for conservation of life and property. Engineers should lead in preventing fire loss and accidents. In civic industries engineers prevent more fires than fire departments extinguish, and prevent many more accidents than ever occur. Built-in protection is needed as well as warning.

The prospective disposition of surplus war material also offers a number of interesting considerations for agricultural engineers, including rural utilization of fire fighting equipment, war salvage explosives and an endless variety of mechanical units from jeeps to cold storage plants. To these you may add more examples.

The engineering war task and the postwar outlook need the concerted attention of the agricultural engineers of this area. Continuation and strengthening of your wartime coordination of effort should be carried into postwar plans and work by this section. At present we are engaged in keeping war equipment "fit and fighting". Let us be equally prepared and effective when "food . . . will write the peace."

Electric Equipment for Postwar

(Continued from page 120)

scarcely understandable to a farmer or to the average farm wireman, does give rules of safety. So far as I know, there are no generally adopted rules of adequacy *with economy* which can be used as a guide by rural wiremen. Such a guidebook might be a worth-while undertaking for the American Society of Agricultural Engineers.

A Farm Management Approach. Most electric utility engineers and cooperative managers look upon their job as one of building load — getting more kilowatt-hours used on farms. College specialists carry on educational programs on the use of specific pieces of electrical equipment or the more widespread use of electric appliances generally. I only need call your attention to the demonstration farms, the demonstration trucks, exhibits and educational campaigns for you to know this to be true. We have been trying to sell the farmer on electrical equipment. While doing this we have passed through the C.R.E.A. period of equipment development and the TVA-REA period of focusing attention on lower rates as an incentive for increased use. The use of production equipment is still low.

I would like to suggest a different approach. Instead of making our goal and measuring our results in terms of kilowatt-hours, let's "make and measure" in terms of added dollars we can produce for the farmer. Some electric power companies that are doing this have found it so effective that the top executives of the companies are now thinking in terms of improving their business through a general increase in the standards of living and production of the people in the community. This is a farm management approach — a utilization of our knowledge of engineering in working with the livestock specialist, the dairy specialist, the poultry specialist, the horticulturist and the agronomist to save labor, improve and increase products and to enable the farmer to have a more profitable business.

In suggesting this I am still thinking about postwar farm electrical equipment. If we, as engineers, have struck an impasse in the development of production electrical equipment, why not attack the problem with the specialists in different fields, making an analysis of every present operation and possible new development and then trying to apply electricity in some form to improve management and returns in those fields. The project and credit should be in the field of the specialist with the engineer as his aid. I am just visionary enough to believe that with the dairy department and the agricultural engineer of one state agricultural experiment station concentrating on a *job analysis* of dairy farming, and other states concentrating on poultry, horticulture, vegetable gardening or some other specialty, we might arrive at places we have never been before. Surely the national interest in rural electrification is such now that no agricultural research group can ignore it.

On the basis of profitable farm management it is often the little things in electrical equipment which are valuable. The development of a timer for fast milking is one of the little things. It is not even electrical, but it makes the electric milker more effective by greatly reducing the labor involved, improving the flow of milk, and in possibly reducing the spread of the udder disease, mastitis.

The new electric poultry debeaker is another such device. It has been known that removing the upper mandible of the beak prevents feather picking, cannibalism and some feed wastage. Cutting off the end of the beak often caused the birds to bleed to death, or the beak would grow back on. Burning it off electrically overcame these drawbacks. Again, a fan and duct system in the hay mow can make No. 1 hay out of the same crop that would have been No. 3 hay handled in the usual manner.

There is another angle to the farm management or the farmer's-extra-dollar approach. If times should get tough on the farm, it may be the little niceties of farm management that save or make a dollar that will keep the farmer in business and his electrical equipment in use.

Developments in Peanut Harvesting Equipment

By I. F. Reed and O. A. Brown
MEMBER A.S.A.E. MEMBER A.S.A.E.

PEANUT harvesting has become one of the major machinery-development problems in the states of the Southeast because of insufficient labor to handle the large crops the country needs in wartime, with existing equipment and methods. From an average of 1,818,000 acres (according to state reports) harvested per year for the period 1937-41, production rose to 3,425,000 acres in 1942 and 5,202,000 acres in 1943. The peanut goal set by the War Food Administration for the 1944 season is 6,158,000 acres, an increase of 18.4 per cent over last season. Yet this year there will be less labor available and no new or improved types of peanut harvesting equipment will be on the market.

The extent of the peanut growing area, the nature of the crop, the methods of planting and cultivating, and methods of harvesting with conventional equipment have been discussed quite fully by Wm. E. Meek in an article, entitled "Machinery Problems in Peanut Production," in AGRICULTURAL ENGINEERING for February, 1943. It is shown that for 1942 the best available combination of digging equipment for farmers using tractor equipment consisted of blade attachments for their cultivators for loosening the peanuts followed by a side-delivery rake for pulling them out of the ground, shaking off the soil, and throwing them into windrows. Though the side-delivery rake is the best commercial machine available for shaking and windrowing peanuts, it has the following disadvantages: (1) Two operations are required for digging and shaking; (2) the windrow is relatively tight so the vines dry slowly and are difficult to handle, and (3) the upkeep on the rake is relatively high as it was not designed for this job. Many other arrangements have been tried by farmers and a multitude of inventions worked out to handle the job under a specific condition but, as Mr. Meek pointed out, most of these arrangements do not do so well when used under other conditions. The same premise holds true for the 1943 season.

The U. S. Department of Agriculture and two or three of the larger farm machinery companies have attacked this problem cooperatively and individually, and several experimental diggers were used extensively last fall. It is indicated now that each organization will carry forward the development of its unit that showed most promise and attempt to get a few experimental machines into the field for test under all field conditions during 1944. This should bring out some better machines for production for the 1945 season.

Manufacturers of a complete line of farm equipment are emphasizing the development of machines for mounting on their tractors or tractor equipment. Thus the blade type attachment mentioned above was available for only a few makes of tractor cultivators. Country blacksmiths arranged ingenious mountings for attaching the blades to other makes and in many instances made up more or less successful complete digging units. A blade type peanut digging attachment complete with clamps for mounting on almost any type of tractor cultivator was placed on the market last August by a southern manufacturer. This unit, shown in Fig. 1, proved quite satisfactory and materials have been requested for making up several hundred sets for the 1944 season. This will help farmers having tractor-cultivating units for which the peanut handling equipment had not been developed previously.

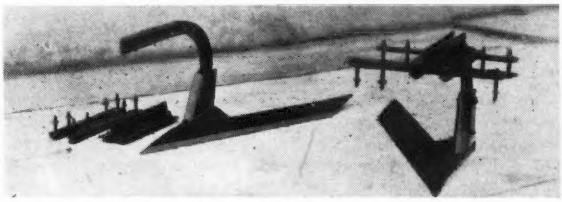


Fig. 1 Peanut-digging attachment with universal type mounting to enable using it on several makes of tractor cultivators

Users of the potato-digger type peanut digger and the vibrating type shaker units encountered about the same difficulties as Mr. Meek mentioned were found previously. An improved, wide-throat unit of the potato digger type was planned but manufacturing conditions prevented building the units. Fifty of the regular-sized machines were built for use in areas growing Spanish or bunch peanuts. They would not handle the runner type successfully.

The consensus of the investigators seems to be that the blade type digger units with single supports are the best. Experience has shown, that if the mechanical shaking operation is to be performed successfully, the plows must not drag the vines into bunches. Some attention has been given to keeping the vines in place during the plowing operation. One method used to prevent dragging is to divide the rows so that the plow support can pass between them without catching onto the vines which have been cut loose. Another method is to place a rubber-tired wheel so that it will roll on and hold in place the vines which are being cut by the plow. With these additions the blade type digging units are doing satisfactory work, so efforts are being concentrated on the development of shaking, bunching, piling, windrowing, and combining equipment. Although it seems probable the peanut pickers could be improved markedly, the engineers making the studies feel they will handle the job pending a more opportune time. At present, three types of shaking arrangements show

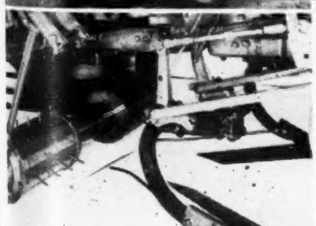


Fig. 2 (Upper left) Single-row bean buncher being used to shake and bunch peanuts • Fig. 3 (Lower left) An experimental peanut shaker using a drum with receding fingers to pull the peanuts and shake the soil out of them. Note the relationship of digger blades, shaker units, and windrowing rods • Fig. 4 (Right) USDA single-row tedder type peanut digger and shaker. May be operated with mules or tractor

This paper was presented at a meeting of the Southeast Section of the American Society of Agricultural Engineers at Atlanta, Georgia, February, 1944.

I. F. REED and O. A. BROWN are respectively, agricultural engineer and associate agricultural engineer, Bureau of Plant Industry, Soils and Agricultural Engineering, U. S. Department of Agriculture.

promise in preliminary field trials and their development is being pushed. They may be classed as (1) receding finger type pickup drum, (2) reversed tedder type, and (3) modified bean buncher.

The modified bean buncher shown in Fig. 2 is said to have done commendable work. The authors have not seen it operate, but find that a large manufacturer is considering developing the unit during the 1944 season. The principle involved has been tried in a number of machines and should prove satisfactory. A two-row machine using power take-off drive and directly connected to the tractor would probably be most desirable.

Two outstanding machines using the receding-tooth cylinder principle were observed. Both were driven from the power take-off, picked up peanuts and discharged them over a cylinder by means of an arrangement of receding teeth, and were raised or lowered by means of the hydraulic-lift mechanism on the tractor. Here the similarity ended. One unit, built in a small shop in central Alabama, was mounted on the rear of a four-wheel, general-purpose tractor and used a relatively large cylinder. A sweep wide enough to dig two rows at a time was mounted on another tractor, thus digging and shaking was a twice-over procedure. This shaker performed especially well considering the small amount of development work behind it.

The other digger using the pickup cylinder arrangement is shown in Fig. 3. The shaker cylinder is relatively small in diameter and works under a tricycle type tractor. The height at which the cylinder is operated is positively controlled by adjustment of the hydraulic-lift control lever. The loosened peanuts are picked up by the cylinder teeth and discharged back over the top of the cylinder. This action shakes most of the soil off the peanuts and leaves them lying loosely on the top of the ground. The action of the fingers and shielding is designed to give minimum wrapping of peanut vines, crab grass, purslane, etc. Windrow rods shown in the background of the picture can be added. They tend to push the two rows together into a fluffy windrow where the peanut vines dry quickly or may be gathered easily if they are to be stacked. The design of this equipment is such that it is possible to furnish various combinations from the blades alone to the completely mechanized peanut harvesting unit, including a combine modified for handling peanuts.

Shaking peanuts with tedder forks similar to those used for hay has been quite completely investigated by the staff of the USDA Farm Tillage Machinery Laboratory. The various types of units developed are shown in Figs. 4, 5 and 6. Preliminary work in 1942 showed that forks arranged to kick back as for hay knocked too many peanuts off the vines. Arrangements with the forks kicking 90 deg to the direction of travel and 45 deg forward were tried. Due to difficulty in getting complete coverage of the row area, the 90-deg angle was abandoned. Indications are that angles between 45 and 55 or 60 deg will be satisfactory. Three types of units have been used successfully: (1) single-row shaker complete with digging blade, Fig. 4, (2) two-row, pulled type, traction-driven, Fig. 5, and (3) two-row, direct-connected, power take-off driven, Fig. 6. The action is at 45 deg forward to the line of travel for the three units shown.

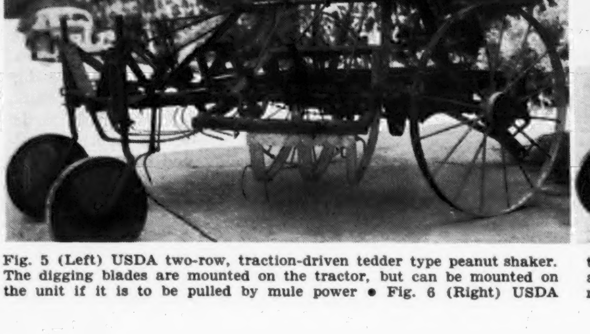
The mechanism operating the forks on the tedder type shakers causes the teeth to have a relatively flat path on the forward stroke, to rise quickly at the end of this stroke, and to return rapidly. This action pulls the peanuts out of the ground, shakes out the soil, and throws them over into the row middle. Using right and left-hand units causes the two-row shaker to leave the two rows in a loose fluffy windrow. They dry quickly in this windrow or can be easily gathered for stacking. The use of the correct gear ratios, crank timing, and width of forks gives complete coverage of the row areas.

Field tests show that the digger blade on the single-row digger-shaker causes excessive side draft on the light unit and causes it to run off the row. A different type digging arrangement will be developed before the 1944 digging season. The peanuts dug with this one-row arrangement are free from soil and left loosely on top of the ground. This type unit was tried in Alabama, Georgia, and South Carolina and it is hoped that these diggers, with the improvements which the 1943 work showed were needed built into them, can be returned to these same states for the 1944 testing.

The two-row traction unit may be equipped with digging blades if it is to be pulled with mules. If pulled with a general-purpose tractor, however, the digging blades should be on the tractor cultivator as shown. This unit served its purpose as a step in the development of the direct-connected unit. The tractor-mounted power take-off driven machine has many advantages. It follows terrace rows better, has more clearance for the windrow, has positive drive, can be maneuvered into fence corners, terrace ends, and for short rows, and is truly a one-man machine. The two-row tedder type shaker has been operated under relatively severe soil and weed conditions and in heavy runner peanuts. It handles all conditions effectively. It can be operated at 4 to 4½ miles per hour so one man can dig, shake, and windrow 25 to 30 acres of peanuts in a day.

The nature of the machinery for handling peanuts will depend upon a number of factors. When peanuts are mature, they must be dug, shaken, and allowed to cure before they are picked and taken to market. Most of the peanuts at present are cured in hand-piled stacks. It is generally agreed that a machine cannot stack peanuts around poles to be cured as is now done. Since a peanut harvesting machine is desirable and necessary if the crop is to compete with other oil-bearing crops, a method of curing peanuts without stacking them becomes important. For this reason experiments have been conducted to determine in what ways peanuts may be left by a power machine for curing.

The data from preliminary studies seem to indicate that the peanut is well protected by the hull and may be cured in a number of ways without undue damage to the kernels. Other important factors, as loss of nuts, value of hay, etc., are affected markedly by weather conditions during the curing process. If peanuts cured in the windrow are left on the ground for a long period because of wet weather, many of them come loose from the vine and are lost. The loss will not be so great if the peanuts are left in stacks or piles for the same length of time. It was observed, however, that peanuts dug and windrowed with one of the machines described in this paper are left in a more favorable condition for curing than when windrowed with a side-delivery rake. The windrow is not compact, thus dries out rapidly and under favorable weather conditions the peanuts were combined three to eight days after digging. *(Continued on page 128)*



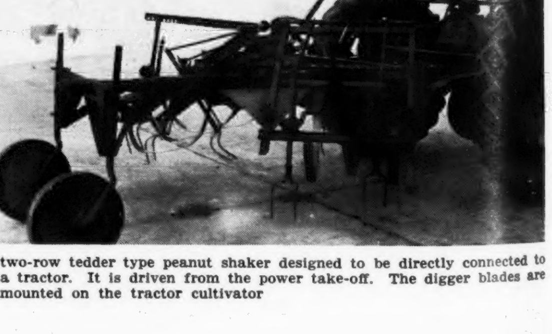


Fig. 5 (Left) USDA two-row, traction-driven tedder type peanut shaker. The digging blades are mounted on the tractor, but can be mounted on the unit if it is to be pulled by mule power • Fig. 6 (Right) USDA two-row tedder type peanut shaker designed to be directly connected to a tractor. It is driven from the power take-off. The digger blades are mounted on the tractor cultivator

Resistance of Soybeans and Oats to Air Flow

By S. Milton Henderson
MEMBER A.S.A.E.

THIS paper which reports a study of the resistance of stored soybeans and oats to air flow is in effect a continuation of a paper published in a recent issue of AGRICULTURAL ENGINEERING relative to the resistance of shelled corn and bin walls to air flow[1]*. Since the apparatus and technique used were discussed in detail in the previous paper, only the results of this part of the study will be reported.

Resistance of Clean Soybeans and Oats. The results of the tests made with soybeans and oats over hardware cloth, free of dockage or fine material and without settling, are given in Figs. 1 and 2. The individual points represent experimental observations. The lines were fitted by eye to the points.

The relationship between the rate of flow and air pressure for a given depth of soybeans is of the form $Q = KP^c$, in which K is a function of the depth of the grain and c the slope of the curve. The values for K and c for soybeans were calculated from the curves in Fig. 1 for the various depths and are tabulated in Table 1.

TABLE 1. VALUES OF K and c FOR SOYBEANS DETERMINED FROM EXPERIMENTAL DATA (FIG. 1)

Depth of grain (D), ft	K	c
0.5	100.0	0.582
1	76.0	0.632
2	50.0	0.591
3	37.5	0.630
4	30.0	0.658
5	26.4	0.666
6	24.0	0.664
7	22.0	0.680
8	20.5	0.681

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

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S. M. HENDERSON is research associate, Iowa Agricultural Experiment Station.

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*Superscript numbers indicate the references appended to this paper.

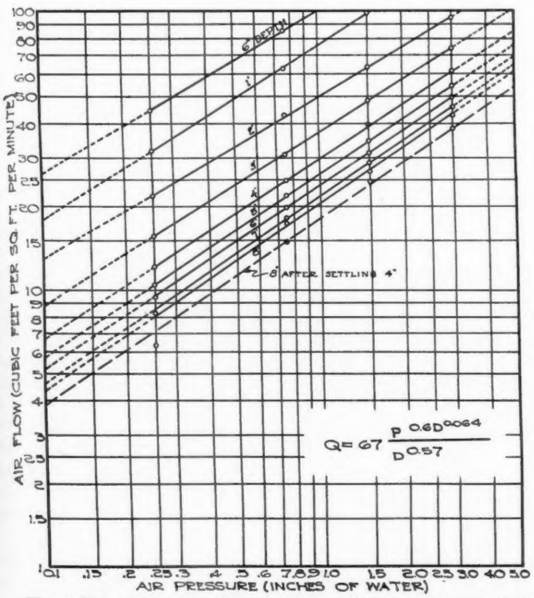


Fig. 1 Rate of air flow through clean soybeans of various depths for various pressures. The beans weighed 55.5 lb per bu; 100 beans weighed 13.0 g. The effect of settling is also shown

The values of K and c were plotted against the depth on logarithmic paper and the mathematical relationships derived. K was found to be 67.0 $D^{-0.57}$ and c, 0.6 $D^{0.064}$. The complete mathematical expression which best represents the experimental data is given in Fig. 1. The formula may be approximated to $Q = 67P^{0.643}/D^{0.57}$, without introducing an error greater than 2 per cent. It is probable that because of the character of the curves the formulas apply fairly well both above and below the observations made in the study.

The curved character of the flow curves for oats (Fig. 2) made a similar simple mathematical interpretation of the data impossible. This same characteristic was exhibited in a small amount of data for grain sorghum which was taken for comparison with available data[3]. Since both of these grains are relatively small as compared with corn and soybeans, association of this characteristic with grain size is indicated. This indicates a problem for future study.

The soybeans were screened through four-mesh hardware cloth and tests made with the graded quantities. The soybeans which passed through the screen weighed 55.5 lb per bu, the same as the blend from which the beans were screened, and 100 beans weighed 12.0 g. The rate of air flow was nearly the same as that of the blend for comparable conditions of air pressure and grain depth. The beans retained by the screen also weighed 55.5 lb per bu but weighed 15.5 g per 100 beans and gave 111 per cent the rate for the original mixture.

Effect of Settling. The effect of settling is indicated on Figs. 1 and 2. Settling was produced by shaking and pounding the stack and by tamping. The rate of flow was 88 per cent of that for the unpacked grain for soybeans and 77 per cent for oats. For ordinary storage situations, the rate of flow would probably be somewhere between these indicated rates and 100 per cent.

Resistance of Perforated Steel Sheets with Grain. The results of the tests with the grain over perforated steel sheets are given in Table 2 and Fig. 4. The sheet types used in the tests are shown in Fig. 3.

An approximate relationship between the resistance of perforated sheets covered with grain and clean grain is shown in Fig. 4. The data for corn were added for comparison.

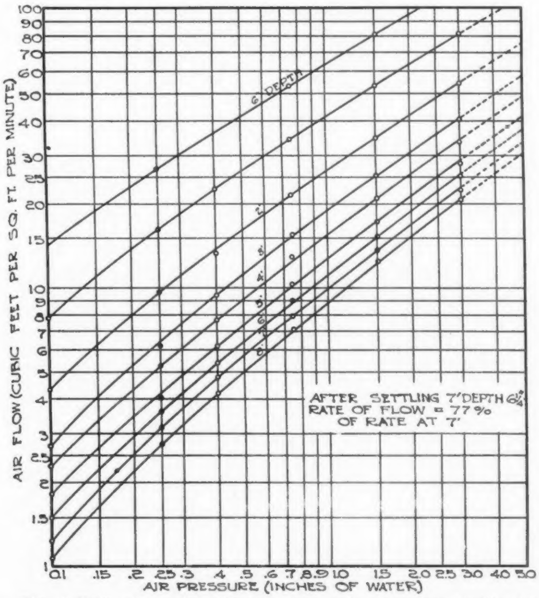


Fig. 2 Rate of air flow through clean oats of various depths for various pressures. The oats weighed 34.6 lb per bu; 100 oats weighed 2.4 g. The effect of settling is indicated.

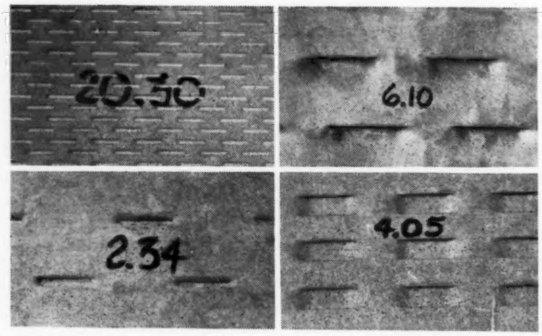


Fig. 3 The four general types of perforated sheets used for resistance tests; the numbers show the per cent of opening. (Type 1, upper left; Type 2, upper right; Type 3, lower left; Type 4, lower right)

TABLE 2. RESISTANCE TO AIR FLOW OF PERFORATED STEEL SHEETS COVERED WITH GRAIN

Type of perforation (Fig. 3)	Amount of sheet open, per cent	Approx. overall width of perforation, in*	Width of perforation opening, in*	Ratio of observed pressure drops across sheets†		Equivalent resistance of perforated sheet with grain (depth of clean grain, ft)	
				Soybeans	Oats	Soybeans	Oats
1	51.00‡	0.18	0.18			0	0
1	20.30	0.06	0.06			0	0
2	6.10‡	0.25	0.13	2.8	4.1	0.7	0.3
3	4.77‡	0.40	0.11	6.1	6.8	1.6	0.6
3§	4.77	0.11	0.11	2.6		0.8	
4	4.05	0.25	0.04	1.6	2.8	0.9	0.4
2	3.30‡	0.25	0.11	2.0	3.8	1.3	0.6
2	2.75‡	0.25	0.12	2.4	2.9	2.6	1.0
2§	2.75	0.25	0.12	2.0		2.3	
3	2.34	0.15	0.07	1.6	3.4	2.1	1.3
3	1.83	0.15	0.07	1.7	3.4	4.0	2.6
2	0.89	0.30	0.09	1.5	5.1	8.7	6.0
3	0.85	0.10	0.05	1.3	3.0	8.0	6.9

*The approximate over-all width indicates the distance across the face of the sheet which is occupied by the orifice and deformed metal which constitutes the perforation. The narrowest perforation width is the width of the actual opening perpendicular to the direction of motion of air through it.

†Ratio of the observed pressure drop across the sheet with grain to that without grain. These values may be assumed to apply at all pressures.

‡Perforations were too large for satisfactory field use with oats. Although satisfactory tests were made, some oats sifted through into the plenum chamber during the filling and emptying operations.

§Sheets reversed so that depressed part of perforation would project into the grain.

Air Flow Through Various Grains. Some air flow data for various grains are given in Table 3. These data are especially intended to be used for comparing the resistance of grains to air flow, but of course may be used in so far as possible as a source of air flow data.

REFERENCES

[1]Henderson, S. M. Resistance of shelled corn and bin walls to air flow. Agr. Engr. 24:367-369, 374. 1943.

[2]Stirniman, G. P., et al. Tests on resistance to passage of air through rough rice in a deep bin. Agr. Engr. 12:145-148. 1931.

[3]Kelly, C. F. Methods of ventilating wheat in farm storages. U. S. Department of Agri. Cir. 544. 1940.

TABLE 3. RATE OF AIR FLOW (cfm per sq ft) THROUGH VARIOUS GRAINS FOR A FEW AIR PRESSURES (inches of water) AND GRAIN DEPTHS

Depth of grain, ft	0.10	0.25	0.50	1.00	2.00	3.00	0.10	0.25	0.50	1.00	2.00	3.00
	Shelled corn						Soybeans					
0.5	21.0	35.0	51.5	76.0	120.0		26.2	44.6	67.0	100.0		
1.0	14.0	24.0	36.0	59.0	80.0	102.0	17.7	33.5	49.0	76.0	115.0	
2.0	10.3	17.3	25.8	38.3	57.0	72.0	12.4	22.0	33.0	49.6	74.5	95.0
4.0	5.9	10.4	16.0	24.3	37.5	48.0	6.6	12.1	19.0	30.0	47.0	62.0
8.0	3.2	5.8	9.3	14.7	23.2	30.4	4.3	8.2	12.9	20.7	33.0	43.5
	Oats						Wheat*					
0.5	14.0	26.5	41.5	63.5	96.0		6.1			54.0	80.0	92.0
1.0	7.8	16.3	26.3	41.5	63.5	81.0	3.8	9.8	18.5	31.5	49.5	62.0
2.0	4.3	9.7	16.2	26.2	42.0	54.5	2.1	4.7	9.2	18.5	31.8	41.5
4.0	2.3	5.2	9.1	15.5	25.5	34.0	1.2	2.1	6.5	11.5	20.5	27.5
8.0	1.1	2.7	5.0	8.9	15.2	20.7	0.7	1.3	2.8	6.9	13.0	18.5
	Sorghum						Barley†					
0.5	13.8	25.0	39.0	57.5	87.5					62.0	92.0	
1.0	7.6	14.3	25.5	40.4	61.4	80.0		12.0	22.5	41.0	63.0	79.0
2.0	4.1	9.5	15.6	25.3	39.7	52.0		9.5	16.2	27.0	42.5	54.5
4.0	2.2	4.5	8.2	14.3	24.0	32.5			10.2	17.0	28.0	37.5
8.0†	1.2	2.9	5.5	9.5	11.5	24.0				11.4	19.2	26.5

* High pressure data from Calif. Agr. Exp. Sta.[2]; low pressure data by Kelly[3].

†From data available from the Calif. Agr. Exp. Sta.[2]

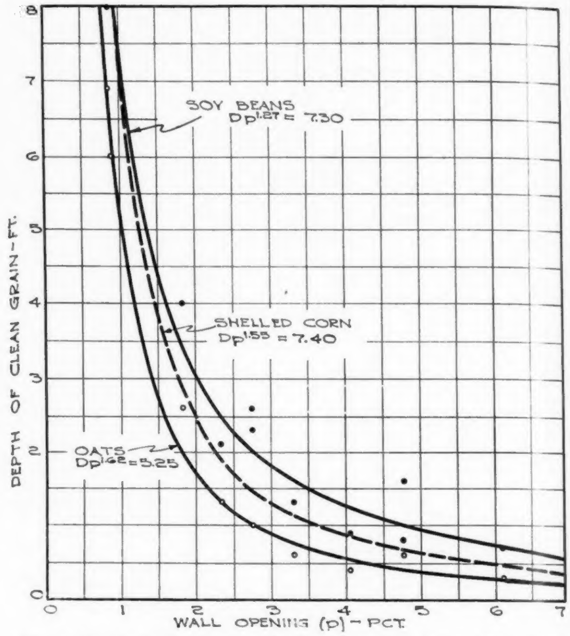


Fig. 4 Resistance to air flow of perforated steel sheets with different openings covered with soybeans and oats. The curve for shelled corn was added for comparison. The resistance is expressed in equivalent depths of clean grain

Peanut Harvesting Equipment

(Continued from page 126)

Some consideration has been given to harvesting peanuts as two separate crops, hay and peanuts. The hay crop is mowed, cured, windrowed, and baled, either with a pickup baler or stationary unit. The peanuts are then dug and consist only of the peanuts and the root stalks. These peanuts and roots may be cured in piles or windrows or they may be stacked and picked in the usual way. The windrows or piles can be picked with a combine or hauled to a stationary picker. This method should give a very good quality of hay though the peanuts may be a little more difficult to handle. If the peanuts are not left in the ground too long, there will be little if any deterioration due to the tops having been mowed off.

The best figures we have been able to obtain from economists and agronomists indicate that peanut harvesting operations, including picking and hauling the nuts to the warehouse, require about 40 man-hours per acre by the methods used on most of the small farms. The peanuts are plowed out with a one or two-mule unit, pulled, the soil shaken off, and the vines thrown into piles by hand, stacked on poles, hauled or dragged to the picker, the nuts picked off and hauled to market. According to our best judgment, using either of the digger shaker units described above and a combine for picking the peanuts directly from the windrow would require ½ man-hour per acre for the digging, shaking, and windrowing operations and 2 to 4 man-hours per acre for the combining and marketing operations. The spread in man-hours per acre is from a high of 40 to a low of about 3. It is not assumed that the hand methods of harvesting can be immediately replaced by power machines, but in the near future machines will be available which will take much of the toil and time out of peanut harvesting. Since the method of harvesting necessarily is affected by the type of soil, size of farm unit, how the hay crop is to be used, and other factors, the farmer can then choose the equipment and methods that best fit his conditions.

The Agricultural Engineer in the Postwar Period

By Arthur W. Turner
FELLOW A.S.A.E.
President, American Society of Agricultural Engineers

FOOD and only food can preserve a starving world. Thus American agriculture finds itself at the world's crossroads, and all activities allied with it — scientific and technological processes as well as production facilities — must deliver or civilization will suffer. Agricultural engineers are included in this. Goods are needed to develop a productive world-wide agriculture that can feed the hungry nations and promote a lasting peace. It is the agricultural engineers' opportunity and responsibility to inform America on the peacetime importance of food and to aid industry in developing new and needed agricultural goods. These include crop production tools, transportation devices, animal shelters, crop storages, processing units, farm home utilities and numerous other items for the use of agriculture here and in other countries of the world.

We need to make people of this country appreciate that agriculture is not static. They must realize the farmer's need for new goods to reduce production costs and improve the crops he produces; they must realize that engineering is the key to further agricultural development. Without real effort on our part, the general public will not appreciate our accomplishments and the need for further development. One of our important tasks is cooperation and coordination within and without our ranks.

We live in a modern, civilized world, yet 66 per cent of the population the world over is farmers. At least they live on the land and produce their living from the soil. Two families the world over are required to produce food for themselves and just one other family in other walks of life. If we subtract America where one farm family produces an abundance for itself and four other families, the foreign farm ratio picture is still darker.

The rest of the world looks to us for technological leadership and offers unlimited opportunities for our manufactured goods. In fact, that is essential if farmers of other countries are to produce all or most of their food and clothing.

More goods are still needed to meet food demands. In fact, more goods (equipment especially), properly engineered and made available to the agriculture of the various nations will promote two peace stabilizing factors, namely, stimulate industry and increase the standard of living in all countries.

While American farm machinery is recognized as highly developed today, there is still much to be done in mechanizing small farms and many operations in producing domestic crops. In addition, equipment must be available to handle the new crops being adapted to this country. There are also special crops being grown under American supervision in Latin-American and other countries. We hear of the thousands of acres of rubber and medicinal and other herbs and plants. Do they have the proper equipment?

Only 13 per cent of our corn is harvested with mechanical pickers and the number of practical cotton pickers, the bottleneck of mechanization of cotton is still very small. Among crops calling for mechanization in the South are cotton, sugar cane, peanuts, and sweet potatoes. I am informed that any crop can be stored safely for 5 years if it is dry enough; even insects will not affect it. Experiment stations in this area have done yeoman service in drying hay and vegetables. Are they ready to turn this work over for mass production, or do we first need automatic temperature and humidity control?

Electricity has come to agriculture and 35 per cent of the farms have been electrified. Early additions will probably double that number. These farms will demand more applications of electricity—for power, temperature control, health, and nutritional benefits. Then picture such jobs as putting hay in the mow, unloading silage and sugar cane, initial processing of soybeans to eliminate hauling the meal to market and back, and we have a few opportunities for rural electrification research.

This is an abridgement of an address delivered at a meeting of the Southeast Section of the American Society of Agricultural Engineers, at Atlanta, Georgia, February, 1944.

ARTHUR W. TURNER is educational adviser, International Harvester Co.

One of our A.S.A.E. members commenting on farm structures of the future said: "Prefabrication of buildings will move on the farms only if it can successfully compete with present methods and materials." How can buildings be designed and constructed so as to lend themselves to changing types of agriculture? Even in one generation a farm may be operated on a cash crop basis when the young farmer starts out; then with increased family labor change to dairy, and after the children have grown, be converted to a beef cattle enterprise. Possibly buildings that the tenant farmer can move with him from farm to farm like his machinery and household furniture are desirable and practical.

We are realizing more and more the importance of maintaining and improving our farm lands through soil and water management. New soil practice data affects the field machines and possibly the crops themselves. These data have already helped to improve production, and what is more important are saving our soil, the foundation of a permanent agriculture.

We look to state and federal research agencies for information that is obtainable only through cooperation of agricultural engineering and other agricultural sciences. Practical agricultural engineering research is a challenge right now. The new research policy evolving in the U. S. Department of Agriculture is promising. It seems sound and has untold possibilities, but at the moment the agricultural engineering program appears weak.

I would like to comment on observations of research activities I made recently at the Beltsville Research Center. Exhaustive nutrition studies are under way in connection with beef and dairy cattle, sheep, hogs, goats, poultry, and work animals. There are also breeding studies relating to milk, beef, skin, wool, fiber, hog bristle, egg production in poultry, but I found little if anything on housing requirements, humidity factors, temperatures, amounts of air, or use of the newly developed electrical rays. Surely some of these factors should be taken into consideration in connection with the animal studies. Is there not here a great opportunity for more cooperative projects?

Row after row of identical poultry houses, countless numbers of similar hog houses, and cattle barn after cattle barn, all identical from physical characteristics, would indicate that agricultural research workers believe the engineering phase is static. The temperature ranges of the United States from Canada to the Gulf alone should question the wisdom of such an attitude. Animal requirements obviously change with climate and other factors.

Exhaustive nutritional studies are carried on with low-quality grains and feeds, materials devoid of or in varying stages of vitamins and mineral content. I hazard the statement that, if the animal scientists in cooperation with agricultural engineers tell us the desired analysis of feeds, we will quickly find a way to process, cure, or handle crops to meet the standards set up. Hay drying studies at Virginia Polytechnic Institute, by Tennessee Valley Authority, and other stations are evidence of what we can do.

I observed work at Beltsville on crops, vegetables and flowers wherein light and length of day are studied to obtain their effect on blossoming, size of plant, and productivity. Surely applying electricity — its various rays, amperages, voltages and frequencies—might prove most enlightening in connection with problems of ailing and housed animals. The building and electrical industries would appreciate information on such things.

Extensive studies of long standing show the effects of various cover crops and cultivation in orchards. I failed to obtain any information on work in cultivation; for example, how deep for various soils, frequency of cultivation or proximity to surface and subsurface roots. These seem likely problems applicable to all fruits in all climates and soils.

Refrigeration, dehydration, and other applications of temperature are two other timely subjects. Numerous investigations show picking and temperature effects on fresh fruits and vegetables. Other work on frozen meats, both commercially and for home and locker freezing, indicates that more research is needed. If this research is

cooperative with agricultural engineering, and has as its objective obtaining proper temperature controls and periods for proper freezing and storage, I feel that the desired units could be built. The same is true of any household appliance or utility. Investigations of present units is merely a check on the manufacturer in meeting present *arbitrary* standards and can hardly be classified as basic research.

By the same token exclusive agricultural engineering research will discover little, if any, basic production data. Our work must be cooperative with allied agricultural sciences. The valuable work on fertilizer placement, sugar beet equipment, and corn growing methods show what can be accomplished in cooperative programs. Perhaps much work is under way but if so industry and the public are not aware of it.

The test of agricultural research is its practical value to farmers. Will the results of the research improve rural living and increase farm income? The findings of agricultural engineering research, unlike that of other sciences, invariably have to pass through the hands of a manufacturer to benefit the farmer. This is true whether the research calls for new practices, for new or improved machines, new buildings, materials, new types of structures, applications of electricity, ventilating mechanism, household equipment or what not. For that reason I contend that agricultural engineering research, whether by state or federal agencies, should be conducted in close cooperation with the various industries to the end that the results of research are made available to farm people as quickly as possible.

The farm equipment industry wants to know about research results that offer opportunities for manufacture, that is tools and materials for the farmer. The industry wants the complete answers, and if state and federal research agencies together cannot give them, it may be necessary for the industry to expand its own research facilities. I for one hope that will never be necessary, for the federal and state experiment stations, strategically located throughout the country, are ideally situated to obtain the facts needed.

Other countries realize the need of basic research including agricultural engineering research, to improve their agriculture and forestall famine. Recently I had the opportunity to discuss agricultural production problems with representatives of two other nations. In both cases these men said they needed to solve many problems in the production, storage and processing of their farm products in order to rebuild their countries.

The peoples of many other countries rely on America's assistance in regaining their place in the world. They realize that the American way of doing things stems back to American freedom. Free to work, free to move, free to think, free to apply his initiative, free to enjoy his rewards, the American has led the world in finding out what the good earth is for. Because he has been able to produce abundantly, he has been able to live abundantly.

It is my opinion that other nations will strive to gain more of America's freedom. The success of such efforts will depend in large measure on how well those nations can feed themselves. We as agricultural engineers can, if we are ready and willing, stimulate industry to produce more agricultural goods for us and many other countries of the world, that will enable their people to produce more abundantly, to live more abundantly, and thus to live in peace — all to the end of promoting and continuing peace with their neighbors.

That is a definite objective of agricultural engineering — coordinating all activities and interests involving engineering service to agriculture. It calls for unified thought and action on our part. We need a strong society of persons who appreciate the needs of engineering in agriculture. Our success in fulfilling that responsibility is up to each one of us. We should be proud to be agricultural engineers, but not to rest on our oars. There is a big job for us ahead. Let's give it our very best!

"Contour Fencing"

TO THE EDITOR:

WE HAVE been much interested in the editorial in AGRICULTURAL ENGINEERING for March, entitled "Contour Fencing." We have been working on fencing problems for a number of years in cooperation with the Farm Fencing Association, which formerly went under the name of the Pressure Treated Fence Post Institute. Some of the results have appeared in AGRICULTURAL ENGINEERING, under the titles "Construction of Fence Ends and Corners" in the April, 1940, issue and "The Overturning Resistance of Wood Fence Posts" in the May, 1943, issue. The latter article is of particular interest in contour fencing because it points the way toward the securing of greater overturning resistance which is more of a problem in contour fencing than in straight fencing.

Considerable work has also been done toward the reduction of labor in fence construction by driving posts or by setting turned posts in holes bored to exact size. From observations made in connection with these tests it is apparent that the destruction of fence ends may be the result of stretching the barbed wire. Whereas woven wire fencing is provided with tension curves which tend to equalize the load despite great changes in environmental temperature, such provision is not made with barbed wire. The result is that the tension on the fence end is greatly increased in cool weather. It would appear feasible to provide some means for equalizing the tension in barbed wire particularly when fences are built on the contour.

I concur with the point made in the editorial that this is an important problem, and I just wanted to call your attention to the fact that we are now working on it.

HENRY GIESE

Professor of agricultural engineering
Iowa State College

Flue Curing of Chopped Hay

TO THE EDITOR:

I AM sending a copy of a letter from a dairy farmer in eastern Ohio which illustrates the crying need for information on the flue curing of chopped hay. *Practically none is available.* One eastern agricultural experiment station may start some work this season in a very limited way, but other stations, as far as we know, have nothing on fire along this line.

I would like to see AGRICULTURAL ENGINEERING give at least brief editorial attention to the need for investigation in other parts of the country.

Virginia Polytechnic Institute and others have recently shown that flue curing adds many dollars a ton more than its cost to the average value of hay crops through the practical elimination of leaf losses, bleaching and mow burning.

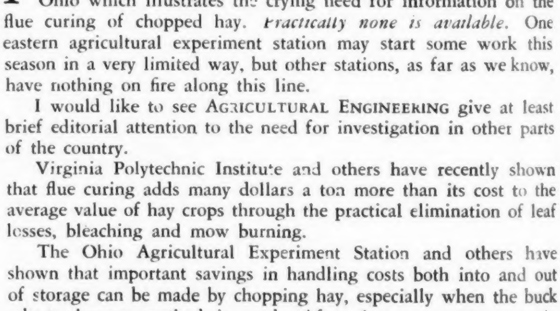
The Ohio Agricultural Experiment Station and others have shown that important savings in handling costs both into and out of storage can be made by chopping hay, especially when the buck rake-to-chopper method is used. After the war greater cuts in handling costs will be made possible as field choppers become available.

Chopped hay is subject to exactly the same losses that can be eliminated from whole hay by flue curing. Is it not reasonable to assume that the successful adaptation of flue curing to chopped hay would mark another important advance in the drive toward better hay at less cost?

If uniformity of density in the stored hay is a principal requirement of successful flue curing, is it not also reasonable to suspect that chopping may have as much to contribute to the success of flue curing as vice versa?

FRANK K. HAMLIN

Vice-president, Papec Machine Co.



Studies of Raindrop Erosion

By W. D. Ellison

MEMBER A.S.A.E.

RECENT experimental studies at Coshocton, Ohio, have shown that in addition to the soil moved downslope by flowing surface water, some soil is carried downhill by the splash from raindrops. When falling raindrops strike either the soil surface or a thin film of water covering the surface, soil and water particles are splashed into the air. If the raindrops fall vertically onto the surface of a hillside, they tend to strike glancing blows and the splashed soil is mostly thrown downhill. Another cause for the splash moving soil toward the base of the hill is that the particles moving downslope travel greater horizontal distances than those directed upslope.

Other actions in the raindrop erosion process, and of prime importance in problems of soil and water relations, have been found to include breaking down soil aggregates and muddying surface waters before infiltration takes place. The pore openings in the soil surface, partially reduced by the initial breakdown of the aggregates, are still further closed by deposits from the infiltration which contains small fragments of the aggregates and some silt and clay particles.

A broad grouping of the factors affecting raindrop erosion processes would include (1) variables of rainfall, (2) slope of the land, (3) soil characteristics, and (4) protection of the soil against, or its exposure to, rainfall impact. The experiments reported in this paper were designed for studying relationships of rainfall intensity, drop size and drop velocity to raindrop erosion processes. Only one soil type, one slope, and a bare, loose, air-dry soil were used for all tests.

In some of the exploratory experiments used for observing splash phenomena, soil was placed in small cans so as to reduce the runoff and to assist in isolating the factor of raindrop erosion. In other experiments small plots were used, but only one soil (Muskingum silt loam with No. 4 erosion) was tested.

To measure the soil transported by raindrop splash, some new devices were needed. These were developed during the course of the investigations and they are described in another article[4]*.

With the rainfall applicator used[5], the raindrop velocity, drop size, and rainfall intensity could be varied independently. While controlling these factors the effects of changes in each variable on raindrop erosion were studied. For these studies, velocities of raindrops were limited to a maximum of 19.2 fps (feet per second) and to a minimum of 12.0 fps. Drop sizes of 3.5 mm and 5.1 mm were applied and rainfall intensities included rates of 4.8, 6.6, 8.1, and 14.8 iph (inches per hour).

Most of the measurements and samples taken during this experimental work pertained to raindrop splash, but in order to study some of the effects of raindrop impact and the associated splash on soils not found in the splash samples, soils contained in the surface flow on the plot as well as that in the runoff at the bottom of the plot were tested. In one series of experiments samples were taken from the soil surface following rainfall. Analyses of samples included quantity determinations as well as determinations of aggregate sizes, and soil-particle size distributions.

Since these investigations represent a type of erosion study different in both technique and objective from that of measuring soil loss in the runoff waters, a clarification of terms becomes desirable. For this clarification the following terms are described:

1 *Loss of soil through surface runoff*. This is the soil carried off an area by the runoff waters. The amounts carried are largely controlled by the concentration of flow, the density of channels, the hydraulic efficiency of channels, the gullying which takes place, and by the erosional activity over the entire surface of the land.

2 *Loss of soil through raindrop splash*. This is the soil carried off a given area by raindrop splash. Major meteorological factors affecting this loss are sizes of raindrops, intensity of rainfall, raindrop velocity, and wind direction and velocity.

3 *Erosional activity*. This is a process of soil movement and it refers to displacement of soil particles from initial positions regardless of whether or not they are carried off the field or watershed. The displacement may be caused by either raindrops or by flowing surface water. Through erosional activity thin soils can be made thinner and thick soils can be made thicker; top soils may be buried under subsoils, either in valley bottoms or on hillsides; soil structure may be destroyed through breaking down aggregates, and this breakdown may increase rates of water and soil losses.

4 *Erosional damage*. This refers to damages resulting from both soil loss and erosional activity. On some watersheds the soil lost in runoff waters represents only a small part of all the erosional damages. Other damages are caused by actions described as occurring under erosional activity; for example, such as breaking down soil structure, depleting soils of their fertility elements, making thin soils thinner, thick soils thicker, and the burying of topsoils under subsoils.

There are no reports showing that the soils transported by raindrop splash have been measured or analyzed by others. Inadequacy of equipment has delayed studies of splash phenomena, and many of the actions involved have been difficult to detect and identify with the specific results they produce. The process of erosion by splash is usually not apparent to the eye because of high velocities of particle movement, and also because of unfavorable conditions of light and background. So long as the process is not recognized, the results it produces are usually attributed to surface flow, which, like the splash, removes soils from the hilltops and deposits them at points farther down slope.

Although previous measurements have not been made of splash erosion, investigators have long recognized that raindrops striking the soil surface cause erosion. As early as 1877, Wollny described the effect of a beating rain breaking down the soil, in washing fine particles into the tiny crevices and pores, in sealing the soil surface and thereby decreasing porosity, and that of a cover in decreasing just such effects[11]. Research since that time has tended to confirm Wollny's observations and to treat aspects of the problem which he did not stress.

Lowdermilk, in studying the effects of forest litter, concluded that the formation of a fine-textured layer at the surface of a bare soil by the filtering of suspended particles from percolating muddy water was the decisive factor in increasing the surficial runoff from bare surfaces[9]. Other experiments have helped confirm the facts leading to this conclusion[6]. Duley and Kelly described and photographed the formation of a compact surface layer which greatly reduces the infiltration rate and showed the effect of mulch in preventing its formation[3]. They regarded the surface conditions as having a larger influence on the infiltration capacity than have soil type, initial moisture content, and rainfall intensity combined.

Borst and Woodburn[1] working with plots 6x29 ft compared the soil losses resulting from the application of artificial rainfall to a bare soil, to a soil covered by a mulch and to a soil having a mulch supported an inch above its surface, and concluded that the elimination of raindrop impact with its destructive effect on the soil surface, rather than the reduction of overland flow velocity, appeared to be the major contribution of the mulch in reducing soil loss.

Laws discovered that the rate of infiltration after ¾ hr of rainfall decreased with an increase in the kinetic energy of the drops falling per unit area. He also found "that the erosional losses, which were measured in terms of the concentration of the soil in the runoff water, increased by as much as 1200 per cent", as the drop sizes were increased[8].

The physical properties of raindrops have been mentioned or stressed in other experiments. Cook believed that raindrop velocity was one of the variables in the water erosion process[2]. Neal and Baver described a device for measuring drop impact, mentioning the momentum per unit area as a property of rainfall[10]. Horton in considering the effects of rainfall intensity and drop size on infiltration regarded energy per inch of rain as the important property[7].

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

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*Superscript numbers indicate the references appended to this paper.

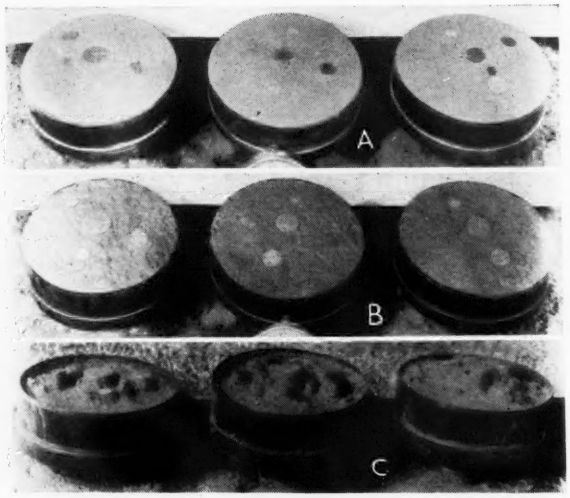

Fig. 1 (A) Soil samples prepared with coins on surface, before rainfall was applied. (B) Samples 45 sec after beginning of rainfall. (C) Samples 1 hr and 15 min after beginning of rainfall

EXPLORATORY EXPERIMENTS FOR OBSERVING RAINDROP EROSION

Exploratory experiments were carried on for purposes of observing splash phenomena and identifying specific erosion processes involved. While this part of the experimental work was in progress, some of the equipment was developed and final plans for the studies were largely completed.

For the first of these experiments, the large stones were removed from an air-dry soil by passing it through a screen with four openings per square inch. The soil was then placed in the tops of standard rain gages, as shown in Fig. 1, and artificial rainfall was applied. Intensity of application was 6.6 iph, drop size 5.1 mm, and drop velocity 19.2 fps. A in Fig. 1 shows three soil samples with coins placed on the surface, before rainfall was applied; B shows these same samples 45 sec after rainfall started (note soil splashed on the white backboard), and C shows these samples 1 hr and 15 min later (large quantities of soil splashed by the raindrops can be seen on the backboard). Since the rainfall produced very little surface flow, the greater part of the erosional loss shown in C may be ascribed to raindrop splash.

Fig. 2 shows a plot severely eroded by raindrop action. These pictures of the soil surface were taken after 5 hr of rainfall, applied at the same intensity, drop size, and drop velocity as described in the preceding paragraph. None of the stones had been screened out of this soil, and after small amounts of erosion had occurred many stones were exposed on the surface and these tended to retard the erosional action of the raindrops. These surface stones were especially effective during the latter part of the experiment.

A in Fig. 2 shows the upper end of the plot and here more soil splashed down slope than was splashed back up to replace the loss. Also, there were some additional losses through splash which carried soil materials out over the plot borders.

B in Fig. 2 includes the entire plot of which a section is shown in A. In this picture erosional deposit can be seen near the base of the slope and particularly on the lower third of the plot length.

To continue with the exploratory observations of raindrop splash, a plot was prepared in a darkened room and a mirror was used to reflect a sunbeam across the soil surface so as to obtain a photograph of the splash while applying artificial rainfall (Figs. 3, 4, and 5). The photograph of Fig. 3 was made with an exposure of 1/25 sec, Fig. 4 is an enlargement of a portion of Fig. 3, and Fig. 5 is an enlargement from a picture taken with 1/100-sec exposure. The vertical streaks in these photographs indicate paths of falling raindrops, while the parabolic curves in Figs. 3 and 4, and the short lines which tend toward the horizontal in Fig. 5, indicate paths of soil and water particles contained in the raindrop splash. In these experiments, where the raindrop splash was photographed, the rainfall intensity, drop size, and drop velocity were 6.6 iph, 5.1 mm, and 19.2 fps, respectively.

Where paths of soil and water particles describe parabolic curves such as are seen in Figs. 3, 4, and 5, it would be expected that maximum distances of particle travel would be about four times the height of rise. An experiment was set up to check these distances and to observe how far the different particle sizes of soil would be carried by the splash. A sample of soil was prepared as shown in Fig. 1 and set on a white sheet, and artificial rainfall was applied. When using a drop size of 5.1 mm and a drop velocity of 18 fps, the maximum distance of splash was found to be 5 ft. Some stone fragments as large as 4 mm were splashed 8 in and soil aggregates and particles of 2 mm were carried as far as 16 in.

In a second experiment, drop size was reduced to 3.5 mm, and this change reduced the drop velocity to about 17 fps. Under this rainfall the maximum distance particles were splashed was about 3.5 ft, and some soil aggregates and stone fragments of 2 mm were carried as far as 8 in.

It was observed that raindrop impact, under certain conditions, would move stones as large as 10-mm diameter when they were partially or wholly submerged in water. When raindrops would strike these submerged stones, the stones would rise and frequently they would move some distance down slope. Where there was surface flow, this would assist the downhill motion even though the surface flow acting alone would not move them.

Following an exploratory test of 1½ hr duration, with rainfall at 6.6 iph, drop size 3.5 mm, and drop velocity at 18 fps, three 10-lb. samples of soil were scraped from the surface cutting to about ½-in depth. One sample was taken from the upper end of the slope, one from the center of the slope, and one from the lower end of the slope. All clods and large aggregates were broken down using a rubber pestle in a mortar, and the samples were then screened, first through the 8-mm screen and then through the 2-mm screen. Results of these screening tests seemed to confirm previous observations by showing greater percentages of large stone on lower portions of the plot, thus indicating a downhill movement of stone fragments as large as 8-mm diameter. The results are summarized as follows:

Sample from top of slope		Sample from center of slope		Sample from bottom of slope	
81.5%	< 2 mm	74.0%	< 2 mm	70.2%	< 2 mm
14.0%	2 - 8 mm	20.5%	2 - 8 mm	21.5%	2 - 8 mm
4.5%	> 8 mm	5.5%	> 8 mm	8.3%	> 8 mm

Fig. 2 (A) This shows upper portion of plot 5 hr after beginning of rainfall; note stones supported by soil columns as in (C) Fig. 1. (B) This shows entire plot of which a section is shown in (A). There is some soil deposit on extreme lower portion of the slope

CONTROLLED EXPERIMENTS FOR STUDYING VARIABLES

The exploratory experiments previously described indicated that considerable amounts of soil materials were carried by raindrop splash, and following their completion plans were made for analyzing samples of this splash to determine physical properties of the soils, the amounts carried, and relationships of these factors to the intensity, size and velocity of raindrops. In some of this work, in addition to studying the raindrop splash, both the soil carried by the surface runoff and that remaining on the surface following rainfall were tested to determine the disposition of the different particle and aggregate sizes contained in the original soils. Experiments were of 30-min duration and different values of raindrop velocity, drop size, and rainfall intensity were used.

The plot was that shown equipped with splash samplers in Fig. 6. A flow sampler[4] can be seen on the lower end of the plot, at the left. Splash samplers were set so that the lip would be ½ in above the soil, and splash plates were set perpendicular to the soil surface. The plot was prepared by spreading approximately 1½ in of top soil over fine gravel about 14 in deep. The top soil was air-dried and all stones and clods larger than ½-in diameter were removed by screening. Six-inch tile were laid in the gravel and good outlets were provided to afford drainage which would prevent backing up of subsurface water into the surface soils. The plot was 5 ft long by 6 ft wide with a slope of 10 per cent. Fresh soils were spread over the surface for each separate experiment.

Soil Particle Sizes in Raindrop Splash. Soil particle sizes contained in the samples of raindrop splash, as well as those contained in the original soils, are shown in Table 1. Each value tabulated represents an average of three determinations, except for those marked with an asterisk, and these represent averages of two determinations each. Averages of all values included in Table 1 indicate that the samples of splash contained a greater percentage of sand and gravel than did the original soils. This increase was from about 25.3 per cent for the original soils to 31.2 per cent for the samples of raindrop splash.

Soil Particle Sizes in Runoff. After it was found that the samples of splash contained greater percentages of sand and gravel than were contained in the original soils, samples of the surface flow were collected from the plot, shown in Fig. 6, to determine how the percentages of sand and gravel carried by the flow compared with those of the original soils. A flow sampler was used to collect these samples. One sample was taken from near each corner of the plot, one from the bottom, and one from the top of the slope about half way from side to side. These six small samples were combined into one large sample before making the laboratory determinations.

TABLE 1. MECHANICAL ANALYSES† OF SOIL MATERIALS CONTAINED IN RAINDROP SPLASH

ERODED MUSKINGUM SILT LOAM

Gravel, 2 to 1 mm	Sand, 1 to 0.5 mm	Sand, 0.5 to 0.25 mm	Sand, 0.25 to 0.125 mm	Sand, 0.125 to 0.05 mm	Total sand and gravel, 2 to 0.05 mm	Total silt and clay <0.05 mm
Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Raindrop size, 5.1 mm						
Raindrop velocity, 19.2 fps; height of raindrop fall, 6.7 ft						
3.83	2.58	2.90	3.84	17.28	30.44	69.56
2.34*	3.27*	2.53*	3.70*	21.57*	33.41*	66.59*
Raindrop velocity, 15 fps; height of raindrop fall, 3.9 ft						
1.87	2.87	3.37	4.27	18.01	30.39	69.61
1.52*	2.97*	2.70*	3.82*	22.92*	33.93*	66.07*
Raindrop velocity, 12 fps; height of raindrop fall, 2.3 ft						
1.91	2.97	3.45	4.26	17.06	29.64	70.36
1.20*	2.04*	2.45*	3.88*	26.06*	35.63*	64.37*
Raindrop size, 3.1 mm						
Raindrop velocity, 18.0 fps; height of raindrop fall, 6.7 ft						
1.07	2.18	3.43	3.60	17.00	27.83	72.17
Raindrop velocity, 14.5 fps; height of raindrop fall, 3.9 ft						
0.62	2.18	3.60	4.73	17.75	28.88	71.12
Raindrop velocity, 12 fps; height of raindrop fall, 2.3 ft						
1.00	2.50	4.13	5.11	18.35	31.09	68.91
Analyses of original soil						
0.55	1.81	2.27	3.49	17.16	25.28	74.72

†Values indicated by asterisk (*) are averages of two experiments; all others are averages of three.

Particle-size determinations made from these samples indicated that soil materials in the surface flow were comprised of only about 5 per cent sand and gravel and 95 per cent silt and clay. Results of these determinations are summarized as follows:

Particle Sizes in Runoff	Per Cent of Sample
2.0 - 1.0 mm	0.25
1.0 - 0.5	0.36
0.5 - 0.25	0.49
0.25 - 0.125	0.67
0.125 - 0.05	3.20
Total sand and gravel, 4.97%	> 0.05 mm
Total silt and clay, 95.03%	< 0.05 mm

Soil Aggregates in Raindrop Splash. Soils collected in the splash samplers were analyzed to determine aggregate size distribution. Results of the analyses are shown in Table 2. These data indicate that the samples of splash contained a greater percentage of aggregates smaller than 0.105 mm than did the original soils. This increase was from about 53.5 per cent for the original soils to 72.2 per cent for the samples of raindrop splash. Such increases could be caused by either (1) breaking down of large aggregates under the impact of raindrops, (2) the large aggregates being carried away by surface flow, or (3) the large aggregates being left on the surface of the plot and not carried by either raindrops or surface flow. In some of the experiments that follow, checks were made to determine the disposition of the large aggregates and the possible causes for the increase in small aggregates contained in the raindrop splash.

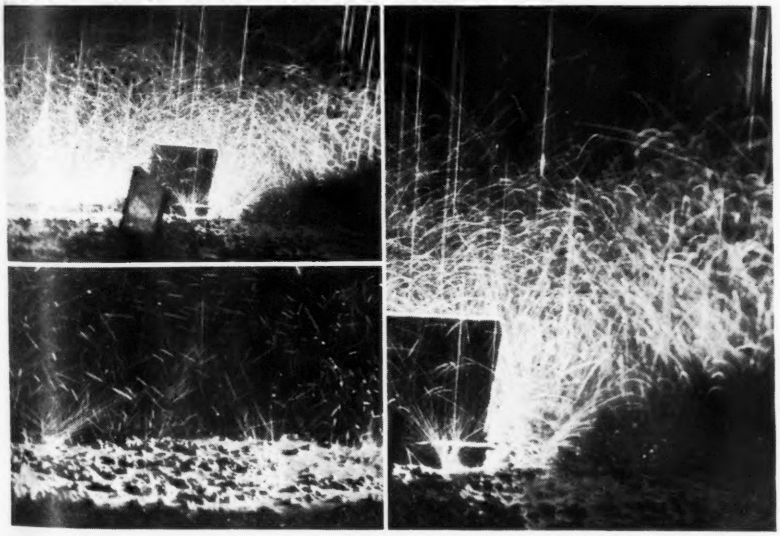

Fig. 3 (Upper left) This photograph was made by directing a sunbeam onto the plot surface during artificial rainfall. Rainfall intensity, 6.6 iph; drop size, 5.1 mm; drop velocity, 19.2 fps; exposure, 1/25 sec. Vertical marks indicate paths of falling raindrops; parabolic curves indicate trajectories of soil and water particles which splash from the soil surface as part of the reaction to the impact of the falling drops • Fig. 4 (Right) This is an enlargement of a section of Fig. 3 • Fig. 5 (Lower left) This is an enlargement of a section of a photograph made in the same manner as Fig. 3, except exposure was 1/100 sec. Long vertical lines indicate falling raindrops, and those lines not vertical indicate particles of soil and water contained in raindrop splash

Soil Aggregates in the Surface Flow. For aggregate analyses of soils contained in the surface flow, samples were collected in the same way they were for studies of soil-particle sizes. The results of the laboratory determinations are shown in Table 3, and these (like the splash) indicate an increase in the percentage of aggregates smaller than 0.105 mm, over and above the percentage found in the original soils. This increase was from about 53.5 to 90.2 per cent. These results indicated that large aggregates not

found in the raindrop splash were not being carried away by the surface flow, and in the following experiments the surface soils were tested to determine if they were left on the plot.

TABLE 2. AGGREGATE* ANALYSES OF SOIL MATERIALS CONTAINED IN RAINDROP SPLASH
ERODED MUSKINGUM SILT LOAM

> 2 mm Per cent	2 to 1 mm Per cent	1 to 0.5 mm Per cent	0.5 to 0.25 mm Per cent	0.25 to 0.105 mm Per cent	< 0.105 mm Per cent
Raindrop size, 5.1 mm					
Raindrop velocity 19.2 fps; height of raindrop fall, 6.7 ft					
2.40	3.89	5.07	5.24	11.38	71.98
Raindrop velocity, 15 fps; height of raindrop fall, 3.9 ft					
1.41	3.68	4.98	5.12	11.53	73.25
Raindrop velocity, 12 fps; height of raindrop fall, 2.3 ft					
1.04	2.87	5.74	6.56	12.11	71.65
Raindrop size, 3.5 mm					
Raindrop velocity, 18.0 fps; height of raindrop fall, 6.7 ft					
0.74	2.87	5.24	6.65	10.83	73.66
Raindrop velocity, 14.5 fps; height of raindrop fall, 3.9 ft					
0.94	2.81	5.66	5.85	10.81	73.91
Raindrop velocity, 12 fps; height of raindrop fall, 2.3 ft					
0.44	2.31	6.25	8.22	13.86	68.89
Analyses of samples of original soils					
13.34	6.33	6.69	8.01	12.05	53.55

*Aggregates include stone fragments.

Soil Aggregates on the Surface Following Rainfall. Following application of rainfall and after runoff had ceased, soil was scraped from the plot surface and determinations were made of aggregate-size distribution. A safety razor blade was used for scraping up these samples from the soil surface, and the depth of scraping did not exceed 1/16 in. Three samples were taken at the bottom, three at the middle, and three at the top of the slope. Each sample was taken on about the quarter point, across the width of the plot.

TABLE 3. AGGREGATE* ANALYSES OF SOIL MATERIALS CONTAINED IN THE RUNOFF†
ERODED MUSKINGUM SILT LOAM

> 2 mm Per cent	2 to 1 mm Per cent	1 to 0.5 mm Per cent	0.5 to 0.25 mm Per cent	0.25 to 0.105 mm Per cent	< 0.105 mm Per cent
Raindrop size, 5.1 mm					
Raindrop velocity, 19.2 fps; height of raindrop fall, 6.7 ft					
0.40	1.68	2.39	2.85	5.27	87.26
Raindrop velocity, 15 fps; height of raindrop fall, 3.9 ft					
0.41	0.91	1.71	2.25	6.25	88.45
Raindrop velocity, 12 fps; height of raindrop fall, 2.3 ft					
0.61	0.56	1.27	1.55	3.95	92.04
Raindrop size, 3.5 mm					
Raindrop velocity, 18 fps; height of raindrop fall, 6.7 ft					
0.47	1.13	1.99	2.14	6.03	88.21
Raindrop velocity, 14.5 fps; height of raindrop fall, 3.9 ft					
0.08	0.66	1.35	1.91	3.02	92.88
Raindrop velocity, 12 fps; height of raindrop fall, 2.3 ft					
0.23	0.80	1.47	1.41	3.64	92.43

*Aggregates include stone fragments.
†Analyses of original soil shown in Table 2.

Aggregate sizes are summarized in Table 4. These samples, like the samples of splash and surface flow, contained higher percentages of aggregates smaller than 0.105 mm than did the original soils. The increase was from about 53.5 to 57.1 per cent.

Upon completion of these aggregate studies it was concluded that some of the larger soil aggregates were broken down by the

TABLE 4. AGGREGATE* ANALYSES OF SOIL MATERIALS SCRAPED FROM THE SURFACE OF THE PLOT FOLLOWING RAINFALL†

> 2 mm Per cent	2 to 1 mm Per cent	1 to 0.5 mm Per cent	0.5 to 0.25 mm Per cent	0.25 to 0.105 mm Per cent	< 0.105 mm Per cent
Raindrop size, 5.1 mm					
Raindrop velocity, 19.2 fps; height of raindrop fall, 6.7 ft					
19.85	4.38	4.47	4.09	12.62	54.56
Raindrop velocity, 15 fps; height of raindrop fall, 3.9 ft					
22.13	5.52	4.33	3.47	7.89	56.62
Raindrop velocity, 12 fps; height of raindrop fall, 2.3 ft					
18.91	4.53	4.62	3.92	7.61	60.37
Raindrop size, 3.5 mm					
Raindrop velocity, 18 fps; height of raindrop fall, 6.7 ft					
18.32	4.77	4.32	4.17	10.23	58.16
Raindrop velocity, 14.5 fps; height of raindrop fall, 3.9					
19.45	5.11	4.63	3.89	10.07	56.36
Raindrop velocity, 12 fps; height of raindrop fall, 2.3 ft					
25.29	4.15	3.39	3.29	7.12	56.73

*Aggregates include stone fragments.
†Analyses of original soil shown in Table 2.

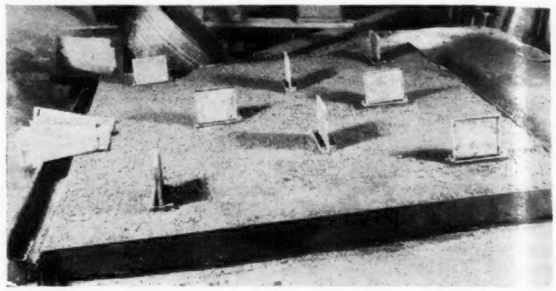

Fig. 6 Splash samplers installed in preparation for an experiment. A surface flow sampler can be seen at the lower end of the plot

rainfall during the experiment. This conclusion was based on aggregate analyses of the raindrop splash, the surface flow, and the surface soils following rainfall, all showing higher percentages of small aggregates than did the original soils.

Quantities of Soil in Samples of Raindrop Splash. Fifty-nine experiments were run for purposes of studying quantities of soil contained in the samples of raindrop splash. For these tests, splash samplers were installed on the plot as shown in Fig. 6.

Values of *E* shown in Table 5 represent the total number of grams of soil caught in the 8 splash samplers during experiments of 30-min duration. These results indicate that quantities of soil in the samples of raindrop splash were increased each time either drop size, drop velocity, or rainfall intensity was increased.

Fig. 6 shows that two of the samplers located midway between the top and bottom of the slope are installed with the splash plates set perpendicular to the length of the plot. Soils caught in upslope sides of the samplers represent materials splashed downhill, while the catch in the downslope sides represents materials splashed uphill. Splash plates were set perpendicular to the soil surface, not vertical.

TABLE 5. QUANTITIES OF SOIL CONTAINED IN RAINDROP SPLASH USING DIFFERENT VALUES OF *d*, *I*, AND *V*

Drop size, 3.5 mm					Drop size, 5.1 mm				
Exp. No.	Distance of drop fall, ft	*V*, fps	*I*, iph	*E*, g	Exp. No.	Distance of drop fall, ft	*V*, fps	*I*, iph	*E*, g
A	6.7	18.0	4.8	267	M	6.7	19.2	4.8	308
A1	6.7	18.0	4.8	176	M1	6.7	19.2	4.8	526
A2	6.7	18.0	4.8	227	M2	6.7	19.2	4.8	504
			Avg.	223				Avg.	446
B	6.7	18.0	6.6	283	N	6.7	19.2	6.6	597
B1	6.7	18.0	6.6	173	N1	6.7	19.2	6.6	505
B2	6.7	18.0	6.6	281	N2	6.7	19.2	6.6	528
			Avg.	245				Avg.	543
C	6.7	18.0	8.1	368	P	6.7	19.2	8.1	690
D	6.7	18.0	14.8	440	Q	6.7	19.2	14.8	679
D1	6.7	18.0	14.8	614	Q1	6.7	19.2	14.8	789
D2	6.7	18.0	14.8	424	Q2	6.7	19.2	14.8	890
			Avg.	492				Avg.	786
E	3.9	14.5	4.8	81.5	R	3.9	15.0	4.8	210
E1	3.9	14.5	4.8	51.9	R1	3.9	15.0	4.8	209
E2	3.9	14.5	4.8	68.0	R2	3.9	15.0	4.8	189
			Avg.	67.1				Avg.	203
F	3.9	14.5	6.6	116	S	3.9	15.0	6.6	242
F1	3.9	14.5	6.6	71.8	S1	3.9	15.0	6.6	171
F2	3.9	14.5	6.6	101	S2	3.9	15.0	6.6	286
			Avg.	96.3				Avg.	233
G	3.9	14.5	8.1	138	T	3.9	15.0	8.1	295
H	3.9	14.5	14.8	206	U	3.9	15.0	14.8	307
H1	3.9	14.5	14.8	190	U1	3.9	15.0	14.8	352
H2	3.9	14.5	14.8	300					
			Avg.	232				Avg.	329
I	2.3	12.0	4.8	17.0	V	2.3	12.0	4.8	51.3
I1	2.3	12.0	4.8	13.6	V1	2.3	12.0	4.8	28.0
					V2	2.3	12.0	4.8	27.8
			Avg.	15.3				Avg.	35.7
J	2.3	12.0	6.6	26.9	W	2.3	12.0	6.6	97.3
J1	2.3	12.0	6.6	11.2	W1	2.3	12.0	6.6	35.1
J2	2.3	12.0	6.6	25.7	W2	2.3	12.0	6.6	52.8
J3	2.3	12.0	6.6	18.4					
			Avg.	20.5				Avg.	61.7
K	2.3	12.0	8.1	33.2	X	2.3	12.0	8.1	67.3
L	2.3	12.0	14.8	49.5	Y	2.3	12.0	14.8	168
L1	2.3	12.0	14.8	49.0	Y1	2.3	12.0	14.8	133
L2	2.3	12.0	14.8	45.0	Y2	2.3	12.0	14.8	170
			Avg.	47.8				Avg.	157

Tables 6, 7, and 8 have been prepared for making comparisons of the relationships between quantities of soils caught in the uphill sides of the samplers and designated by "EU", and those caught in the downhill sides and designated by "ED", when using different drop sizes, rainfall intensities, and drop velocities.

The average ratio of EU to ED, for the 59 experiments included in Tables 6, 7, and 8, is 3.1, and this would indicate that considerably more soil is splashed downslope than is splashed back upslope. Part of this greater downhill movement can be ascribed to the fact that those particles moving downhill travel greater horizontal distances than those moving upslope. Another consideration is the angle at which raindrops strike the surface. The still photographs (Figs. 3, 4 and 5) do not show the greater part of the splash moving downhill, but movies made at the time these photographs were taken show that raindrops falling on this 10 per cent slope tend to strike glancing blows and that most of the splash moves out in downhill directions.

TABLE 6. QUANTITIES OF SOIL CAUGHT IN UPSLOPE AND DOWNSLOPE SIDES OF SPLASH SAMPLERS, EU AND ED, RESPECTIVELY, WHILE USING DIFFERENT DROP SIZES

Drop size, 3.5 mm		Drop size, 5.1 mm	
EU g	ED g	EU g	ED g
962	299	1700	547
$\frac{EU}{ED} = 3.2$		$\frac{EU}{ED} = 3.1$	

TABLE 7. QUANTITIES OF SOIL CAUGHT IN UPSLOPE AND DOWNSLOPE SIDES OF SPLASH SAMPLERS, EU AND ED, RESPECTIVELY, WHILE USING DIFFERENT RAINFALL INTENSITIES

I = 4.8 iph		I = 6.6 iph		I = 8.1 iph		I = 14.8 iph	
EU g	ED g	EU g	ED g	EU g	ED g	EU g	ED g
504	172	637	242	301	71.5	1220	361
$\frac{EU}{ED} = 2.9$		$\frac{EU}{ED} = 2.6$		$\frac{EU}{ED} = 4.2$		$\frac{EU}{ED} = 3.4$	

TABLE 8. QUANTITIES OF SOIL CAUGHT IN UPSLOPE AND DOWNSLOPE SIDES OF SPLASH SAMPLERS, EU AND ED, RESPECTIVELY, WHILE USING DIFFERENT RAINDROP VELOCITIES

V = 12 fps		V = 14.5 fps		V = 15 fps		V = 18 fps		V = 19.2 fps	
EU g	ED g	EU g	ED g	EU g	ED g	EU g	ED g	EU g	ED g
202	70.9	208	74.9	374	122	713	207	1165	372
$\frac{EU}{ED} = 2.8$		$\frac{EU}{ED} = 2.8$		$\frac{EU}{ED} = 3.1$		$\frac{EU}{ED} = 3.4$		$\frac{EU}{ED} = 3.1$	

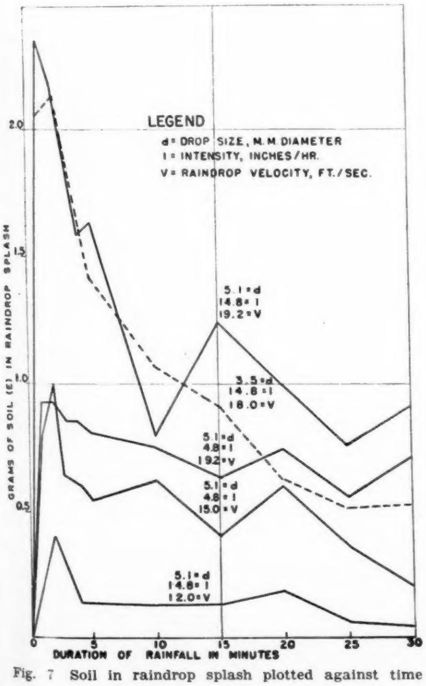

Fig. 7 Soil in raindrop splash plotted against time

Soils in Raindrop Splash Referenced to Time. In this phase of the work both quantities and particle sizes of soils contained in raindrop splash were referenced to time.

In Fig. 7 the quantities of soil contained in raindrop splash are plotted against time for a 30-min period of rainfall, and rainfall characteristics are indicated in the figure. The samples of splash used in this work included those intercepted during one-minute periods for the first five minutes of rainfall, and those intercepted during 5-min periods throughout the next 25 min. Note that all rainfall intensities, drop sizes, and velocities used produced maximum rates of soil splash at between two and three minutes after beginning of rainfall. As in all previous experiments, soils were air-dry at the beginning of the tests.

Observations made during the course of these experiments indicated that the soil surface was mostly sealed against infiltration at the time maximum rates of soil splash were measured. Surface conditions on the plot, during the time of these experiments, were undergoing changes which seemed to exert considerable influence on results obtained.

TABLE 9. SOIL PARTICLE SIZES IN RAINDROP SPLASH FOR DIFFERENT PERIODS OF TIME DURING RAINFALL

ERODED MUSKINGUM SILT LOAM

Raindrop size, 5.1 mm

	Mechanical analysis						
	Sand and gravel					Totals	
Time interval sample taken*	2 to 1 mm Per cent	1 to 0.5 mm Per cent	0.5 to 0.25 mm Per cent	0.25 to 0.125 mm Per cent	0.125 to 0.05 mm Per cent	Sand and gravel 2 to 0.05 mm Per cent	Silt and clay <0.05 mm Per cent
			Raindrop velocity, 19.2 fps				
0-2	2.11	2.51	2.82	3.87	16.09	27.40	72.60
6-8	5.01	2.76	2.97	3.76	18.08	32.58	67.42
13-15	4.36	2.47	2.92	3.90	17.68	31.33	68.67
			Raindrop velocity, 18 fps				
0-2	1.91	2.65	2.75	3.89	16.36	27.56	72.44
6-8	2.79	2.63	3.22	4.75	17.76	31.15	69.85
13-15	1.43	2.46	3.42	4.77	19.69	31.77	68.23
			Raindrop velocity, 15 fps				
0-2	1.20	2.83	3.28	4.27	16.46	28.04	71.96
6-8	2.63	3.49	3.69	4.50	19.55	33.86	66.14
13-15	1.79	2.30	3.13	4.03	18.03	29.28	70.72
			Raindrop velocity, 12 fps				
0-2	1.01	2.22	2.87	4.19	16.14	26.43	73.57
6-8	2.29	3.06	3.69	4.22	17.68	30.94	69.06
13-15	2.44	3.62	3.79	4.37	17.33	32.55	68.45
Before			*Analysis of original soil*				
rainfall	0.55	1.81	2.27	3.49	17.16	25.28	74.72

*0-2, 6-8, and 13-15 indicate time intervals that samples were taken, expressed in minutes after beginning of experiment.

The first raindrops striking the soil tended to break down aggregates and release fine particles of silt and clay. The splash carried some of these particles and as it returned to the surface it was no longer clear water as was the original raindrop; instead, it

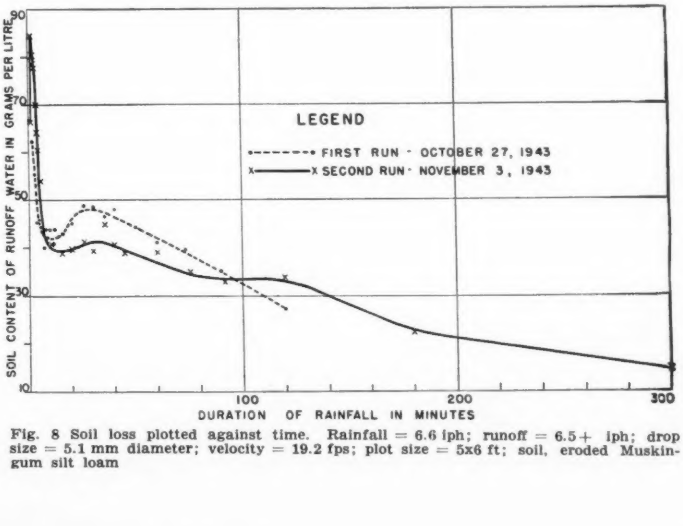

Fig. 8 Soil loss plotted against time. Rainfall = 6.6 iph; runoff = 6.5+ iph; drop size = 5.1 mm diameter; velocity = 19.2 fps; plot size = 5x6 ft; soil, eroded Muskingum silt loam

represented a mixture of water, clay, silt, and sand. At the time this mixture infiltrated, the sand was largely deposited on the surface, and the clay and silt particles were mostly filtered out of the mixture while percolating through the soil mass. The eroded Muskingum silt loam that was used in these experiments seemed to reach an advanced stage of surface sealing within 2 to 3 min after beginning of rainfall.

As the surface-sealing process developed, more and more water was accumulated on the surface, and this accumulation caused the soil materials to be partially submerged, just as a spoonful of soil would be submerged if it were dumped into a large shallow plate containing water. In this analogy, the plane where the soil is sealed compares with the bottom of the plate and the loose soil above this plane compares with the spoonful of soil. These loose materials above the plane of sealing were easily picked up by the splash, and reductions in the maximum rates of soil splash were associated with reductions in amounts of these loose materials.

Particle sizes of sand and gravel contained in the raindrop splash were also referenced to time. After it was found that the splash contained higher percentages of sand and gravel than were contained in the original soils, particle-size determinations were made for the sand and gravel, using three 2-min samples. These 2-min samples were for periods of 0 to 2 min, 6 to 8 min, and 13 to 15 min following beginning of rainfall. The results are shown in Table 9.

Soil Loss in Runoff Referenced to Time. It was thought desirable to obtain curves of soil loss in surface runoff water, as these may be helpful in later studies of the data. Each sample was collected in a quart jar by intercepting for a very short period of time all of the runoff passing off the lower end of the plot. Samples were taken every minute for the first 5 min and at irregular intervals thereafter for a period of 5 hr. Results of these studies are shown in Fig. 8. A smooth curve was drawn through the points, and it will be seen the points define an irregular recession graph.

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(To be concluded in the May issue)

Farm Work Simplification

By Harold E. Pinches
MEMBER A.S.A.E.

FARM work simplification studies are not new in the type of results which are being obtained. Many projects both in agricultural engineering and in farm management throughout the history of these two professions have resulted in simplifying farm work in many ways. The element that is new in the present studies, and which deserves our careful attention, is the technique of analysis developed in connection with the Farm Work Simplification Project. This method of analysis is simply the application to farm work of the principles and practices of analysis which have been so successful in industry, and the technique can be summed up in the terms "process analysis" and "motion study". Enough has been done already by Dean E. C. Young and his colleagues to demonstrate the potential fruitfulness of this method. The results obtained in the past few months point the way to a large field of research.

If this evaluation of the applications of process analysis and motion study of agricultural work is correct, it may be asked why are these current developments so new and so late in arrival? One answer would be that it required the war emergency to focus attention and to create the urgent need for finding ways of doing farm work that are less time and labor consuming. There is, however, probably another and more basic reason. Farming is a series of operations repeated at more or less infrequent intervals. The operations found in agriculture have not received the attention accorded to farm jobs because of the seasonal nature of agricultural work. Haying, for example, is a tremendous job requiring all the capacities of the farm, almost on an emergency basis while it lasts. When done the farmer's attention turns to something else.

As a result of the succession of unlike jobs throughout the year, there is not the same incentive to study component operations as in a shoe factory. Since the shoe factory performs a limited set of operations many times daily, and throughout the year, it is natural to focus attention on smaller and smaller divisions of the job of making a pair of shoes.

Any farm job, such as haying, is made up of numerous operations. Haying involves at least cutting, raking, lifting hay from ground to wagon, building the load, hauling from field to barn, hoisting from wagon into the barn, and mowing away. Most other jobs can be broken down in a similar fashion into numerous elements, each of which can then be studied independently and in relation to each other.

Farm "job" as used here is substantially the equivalent of "process" as distinguished by motion and time study analyses; that is, a group or series of related operations by which a product is changed in form, quality, or location.

Process analysis when applied to farm jobs should result in a record or analysis of the whole job broken down to elements which can be organized under a few simple heads. It should discover and separate operations, transportation, temporary storage, and permanent storage. Another distinction which process analysis may bring out is the *time machines are working* and the *time men are working.* This is especially significant in factories where considerable time is spent in placing parts in clamps or jigs before the machine operation can be performed. However, the same sort of relationship exists in a great many farm operations.

It may be objected that farm operations do not permit the same type of study that has been applied so successfully in factories since the farm is not a factory. Farm work is much more discontinuous and seasonal. As pointed out earlier, thinking about farm work is easily dominated by consciousness of seasonal jobs. However, these seasonal jobs are nothing but complex processes involving the elements of operation, transportation, and storage. All physical work, wherever found, involves repetition of operations which usually can be reduced to simple elements.

Farm operating efficiency is becoming continually more necessary. It may be approached through study of the enterprise (which is typical "farm management"), through reorganization of the processes by which the products of the enterprise are developed, and through analysis and improvement of the operations or the components of any process. At this last stage the agricultural engineer should have a prominent part.

So much attention has been centered in recent years on outside aids and bounties to agriculture, on social and economic aspects of farming and rural living, that there has been some tendency to forget the need for going on with efforts to increase productivity. I am not referring here to increased production, the need of which we are so conscious during these days of war shortage. "Increased productivity" refers to the necessity *(Continued on page 144)*

This discussion followed a talk by E. C. Young, dean of the graduate school of Purdue University, on the National Farm Work Simplification Project before the fall meeting of the American Society of Agricultural Engineers at Chicago, Illinois, December, 1943.

HAROLD E. PINCHES is director of farm practices, Harry Ferguson, Inc.

Hard Surfaced Floors for Poultry Houses

By Ralph L. Patty

MEMBER A.S.A.E.

FOR many years there has been a demand from farmers for a low-cost, hard-surfaced floor for poultry houses. The farmer who asks for this floor wants to build it himself and is usually willing to put a little extra work into the building of it if he can reduce its cost materially.

When the oiled-gravel or "black-top" roads came into general use many requests were received by extension offices and experiment stations asking how poultry-house floors could be built from it. Those who tried it found two things that bothered them seriously. One of them was the fact that the road oil which is mixed with the gravel had to be heated for making the mixture. The other difficulty was in packing and leveling the floor material. The first difficulty needs little explanation. Just as soon as they learned that the oil must be heated most of them dropped the idea immediately. The packing and smoothing of black-top highways is not a difficult matter because it is done in long sections where heavy machinery can be used to distribute and pack it evenly. This method is of course impossible in building a floor. The result was that very few black-top floors were built although they did offer a low cost material for the purpose, and a large majority of farm poultry houses were still left with dirt floors.

In 1939 the South Dakota Agricultural Experiment Station began an experimental study of this problem, which included practical construction methods as well as the floor materials that might prove satisfactory. Eleven different floors are now under test observation in actual service at the station. This does not include the test floors in which variations of thickness, mixture rates, and construction technique were compared. Not all of these eleven floors are new types but the majority of them are. Ten of these floors were built in a 10-pen poultry house which has been used for turkeys, thereby giving them the hardest kind of service. Additional floors were built at other locations in which different mixture rates and construction methods were tested. The eleven floors together with the actual cost of the materials used for 100 sq ft of floor are listed in the accompanying table. All materials were carefully measured and when possible were bought at local retail stores. In all cases retail prices were figured. Since the cost of gravel to farmers varies greatly and is usually low, no cost is included for it.

Type of floor	Cost of materials for 100 sq ft
Zonolite concrete	$17.22
Sawdust-cement concrete	11.10
Common concrete	6.35
Cinder concrete	6.35
Stabilized adobe	5.00
Soil-cement	2.26
Tar, oil-gravel	2.00
Asphalt, oil-gravel	2.00
Raylig (lignin)	1.61
Oil-surface floor	1.54
Plain rammed earth	0.00

Light floors were used in all cases since they were for light service. They were all 3 in thick, except the zonolite, stabilized adobe, and two black-top floors. The zonolite concrete floor has 2 in of zonolite concrete over a 2-in concrete base. The stabilized adobe floor has a thickness of 4 in. The black-top floors each have a thickness of 4½ in. All these floors were built in two course with the exception of the stabilized adobe which was a one-course floor.

This paper was presented at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1943, as a contribution of the Farm Structures Division.

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As indicated, the purpose of the study was to try to develop a hard-surfaced floor of low-cost materials and practical for an inexperienced workman to build. Hand and mechanical methods of mixing materials were tried as well as different methods of packing and smoothing the surface. Different methods of setting up forms, striking off materials, applying oils, and other minor construction details were tried in an effort to find the most practical and convenient methods of construction for the new floors.

It was found that the heaviest hand roller was much too light for packing a 3-in layer of loose material such as was used in the black-top floors and in most of the new floors, so other methods were tried. In previous experimental work with rammed earth, it had been found that a loose material, if evenly distributed, would automatically level out under the stroke of a flat-faced rammer, so this method was tried. Although it was not as rapid a method as we would have liked, it proved very satisfactory in producing a high-density, good-quality floor. Mechanical rammers were quite satisfactory for packing the base course for the new floors and this speeded up the work very definitely. Compressed-air rammers are most practical for this work. They were not used for packing the top courses as they did not leave a smooth enough surface. A foundation or curb around the entire edge was found essential for all of the floors described in this paper, with the possible exception of concrete.

Space will not permit going too much into detail with each type of floor. Only the most important features will be covered in this paper.

Zonolite Concrete Floor. The zonolite concrete floor is the latest floor to be built under this project. Since it is built in the same way as a concrete floor, the setting up of forms and placing of material will be omitted. The specifications of the Zonolite Company were followed in building this floor. This company will be recognized as a manufacturer of a well-known fill insulating material. Their specifications for livestock barn floors are not the same as for poultry houses and only poultry house floors should be built according to method that follows.

A rich concrete mixture — 5 gal of water per sack of cement, was used for the 2-in concrete base. Stiff consistency was used (about 2-in slump) so the top course would be carried immediately.

The 2-in top course was made from a mixture of portland cement and zonolite in the ratio of one measure of cement to three of zonolite (1 to 3). The zonolite aggregate is the same material as zonolite fill insulating material, except that it is slightly coarser and especially graded in size. To this mortar was added a waterproofing material (a thick special emulsified asphalt) sold by the company. Four and one-half quarts of waterproofing and 12 gal of water were used for each bag (4 cu ft) of zonolite. The water-proofing was added to the mixing water. No sand or aggre-

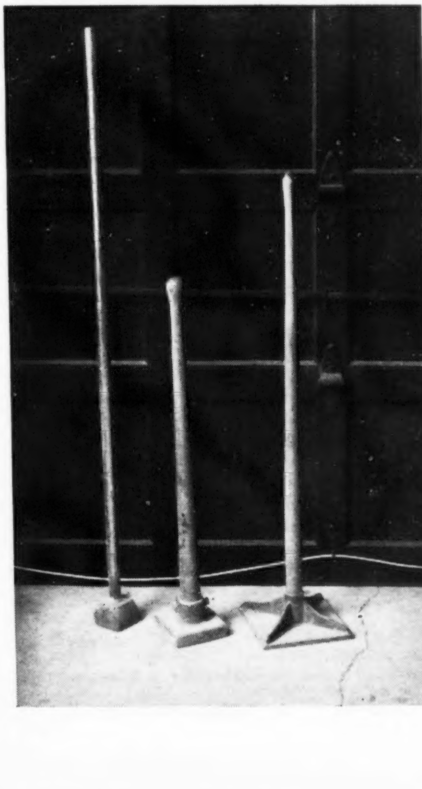


Fig. 1 The only extra tools required for making the new type poultry house floors are one or two hand floor rammers. The shaft of the center rammer has been broken off and should be longer. This heavy 6 x 6-in rammer was used for making an entire floor, but a slightly better floor was built by using a combination of the other two — one small rammer and one 10 x 10-in light rammer. The small rammer was made at a welding shop; the other two were bought from the local hardware dealer

gate other than zonolite was used in this 2-in top course in order to maintain its thermal efficiency and thereby reduce the condensation of moisture. Only one floor of this type has been built as yet, and it has just been placed in service. The cost of this floor was $17.22 per 100 sq ft — not a low-cost floor.

Sawdust-Cement Concrete. This floor has a total thickness of 3 in. A 2-in base course containing no mineral aggregate is overlaid with a 1-in top course made up of one part of cement, one and one-half parts of sand, and three and one-half parts of sawdust (1-1½-3½). Specifications from New Hampshire Extension Bulletin 217 were followed explicitly in building this floor and will be found in that publication. The lower course of this floor was made from a mixture consisting of one part portland cement to three parts of sawdust (1-3). In this type of floor the idea is to reduce the thermal conductivity of the lower course of the floor. White pine sawdust was used. The floor was carefully cured by keeping it covered with very damp sawdust for seven days. The surface required an extraordinary amount of troweling. More water was required than was given in the specifications. The floor was divided into three sections. In the first section the specified amount of water was used. In the second section the water was increased by 10 per cent. In the third section the water was further increased by 10 per cent. Sections one and two have failed. Section three in which 12 gal of water per bag of cement was used is standing satisfactorily after four years. It was rated as a difficult floor for an inexperienced man to build but an experienced workman should be able to build it. The cost of this floor was $11.10 per 100 sq ft, of which $4.78 was for sawdust which cost one cent per pound. This floor was second highest in cost of materials.

Conventional Concrete Floor. This floor was a 3-in, two-course, conventional concrete floor built as a check floor for the nine others in the 10-pen turkey house. Conventional methods of construction were used. The base course had a thickness of 2⅜ in and a water-cement ratio of 7 gal of water to one bag of cement (7 to 1) was used for the mixture. The top course had a thickness of ⅝ in in which a measured mixture of one to two and one-half (1-2½) was used for the cement mortar. The surface was finished with a wood float and cured for seven days. This floor is in perfect condition after four years. The cement cost 75c per bag and the cost was $6.35 per 100 sq ft of floor.

Cinder Concrete Floor. The cinder-concrete floor was built in exactly the same way and with the same dimensions as the conventional concrete floor. The 2⅜-in lower course was made with a water-cement ratio of 7 gal of water to one bag of cement (7 to 1). No cinders were used in the top course. It was made of cement mortar mixed in the ratio of one to two and one-half (1-2½) and with a ⅝-in thickness, making it exactly like the top course of the preceding floor. The cinders used were from Illinois soft coal which had been burned in the college power plant; they were washed but in a manner that would retain as much of the fine material as possible. The amount of portland cement used in this floor measured exactly the same as for the conventional concrete floor. It was finished and cured in the same way. The floor is in perfect condition after four years of service and its cost was $6.35 per 100 sq ft. No charge was made for the cinders used.

Stabilized Adobe Floor. This was a 4-in floor of stabilized adobe laid on a ½-in sand cushion and with mortar-filled joints. Asphalt emulsion was used for stabilizing the adobe soil mixture and the specifications of the American Bitumuls Company of San Francisco were explicitly followed for soil preparation and oil mixtures. Cold asphalt emulsion is used in making stabilized adobe material. The mixing should be done in a plaster mixer machine, but since this machine was not available at the station the mixing was done by hand. This method would be necessary on the farm also. Some work had been done with stabilized adobe building blocks at the station before, so the process was not new.

One-half of this floor was made by making the floor bricks beforehand, curing them, and then laying and leveling them very carefully on the sand cushion. The floor bricks were 12 x 12 x 4 in. Joints of ½ to ¾ in were left between the bricks and filled with a "daggo-cement" mortar. This mortar is one that has been developed at this station for laying up earth blocks in walls, and has proven equally satisfactory in this floor. It is composed of three parts of plaster sand to one part of silt and clay, by volume (S. D. Exp. Sta. Bul. 336).

The other half of this floor was made of the same stabilized adobe laid down in an entirely different way. Instead of making floor bricks of the stabilized material and curing them before laying the floor, the fresh stabilized material (mud) was placed right in the forms for the floor. The surface was floated smooth and the floor was then allowed to dry. As it dried the material shrunk leaving a network of large open cracks. After the shrinkage action had stopped, these cracks were carefully filled with the daggo-cement mortar used with the floor bricks, and the floor was ready for use. The material was both tedious and hard to mix by hand, and the floor blocks were tedious to lay with a smooth surface. The monolithic floor required less time and labor to build and proved to be as satisfactory. There might be a future for custom-built floors of this type. After three years use, these floors were both in excellent condition and withstood washing and disinfecting the same as all the others. The cost of the materials was $5.00 per 100 sq ft and was the same for each of the two floors.

Oiled-Gravel Tar Floor. Oiled-gravel highways are built with two different oils, tar road oils and asphalt road oils. They are quite often called "black-top" roads. The oils are heated in the process of mixing the materials. This heating process is rather difficult on the farm and is the reason why little attempt has been made on the part of farmers to build floors of this material, although many have considered it.

Highway specifications were followed in building this floor and since they are so easily obtained they will not be discussed in detail. A 3-in rammed earth base was used under a 1½-in tar-oiled mat. A priming coat of oil was used between the two courses and a seal coat was given to the surface. The tar-oil mat material was mixed in a concrete mixer. The best method found for mixing it is as follows: The gravel was first placed in the mixer. The oil which had been heated to 185 F (degree Fahrenheit) was then added slowly to the gravel with the mixer running. The silt and clay was then shoveled in slowly as the material was mixed. A varying rate of oil in different sections of the floor showed that a better floor for poultry can be made by increasing the highway specifications for M.C.3 road oil, from 4½ per cent (by weight) up to 5½ per cent. This is an increase in the oil rate of nearly 20 per cent. The surface of this floor with the higher rate of oil is satisfactory after four years. The oil cost 15c per gal and the floor cost $2.00 per 100 sq ft for materials.

Oiled-Gravel Asphalt Floor. This floor was built in the same manner as the tar floor just described. S.C.4 asphalt road oil was used in the 1½-in mat on top. This floor also showed a higher quality surface when the rate of mixing oil was increased by 20 per cent over highway specifications. This floor seemed rough and harsh on the surface and not as smooth as the tar floor. Oil cost was the same, and cost of materials per 100 sq ft was $2.00.

Soil-Cement Floor. The experimental light-traffic highways of soil-cement suggested this type of floor for the poultry house. Soil-cement is a mixture of approximately three parts of sand and one part of soil by weight, stabilized with 10 per cent of portland cement by volume. This floor has been built with several variations, but the test floor in the turkey house is 3 in thick and was built in two courses. The 1½-in base course was made with the same soil and sand mixture as the top course and as given above, except that it contained no cement, and coarse aggregate was used in it up to ¾ in in size. Form strips of 2 x 4-in lumber were staked down the same as for concrete, and the subbase is prepared in the same way. This type of floor was very simple to build. One construction feature that is new and different is that the material is packed in place and the depth of loose material should be controlled so that the thickness of the finished floor will be correct. This is done by striking off the loose material before it is packed so that it will be level and will have the right depth before packing. The floor is built in strips and the floor space should be measured and divided into strips of equal width so that the templates will fit all strips. The most convenient width for the strips was found to be between 5 and 6 ft.

The lower course of the floor contains no stabilizing material. It is the same mixture of soil and gravel that is optimum for road bases. It will contain three parts of sand to one part of soil by weight. The sand contained in the soil must be known in order to obtain this proper mixture and an analysis of the soil must be

made. It is possible to make a home test of the soil that is sufficiently accurate, but laboratory analyses are much more dependable and can be secured at a nominal cost. This loose soil mixture should contain enough moisture so that it will pack well*. The 2 x 4 form boards should be settled until the space for this loose base course is 3¼ in. When it is packed, 1½ in will be left inside the form boards for the finished top course. Since it requires a depth of loose material approximately twice this depth before it is packed, side boards were made for the forms by laying 2 x 4 boards flat along each edge. The form was filled, the loose material struck off and then packed with a hand rammer.

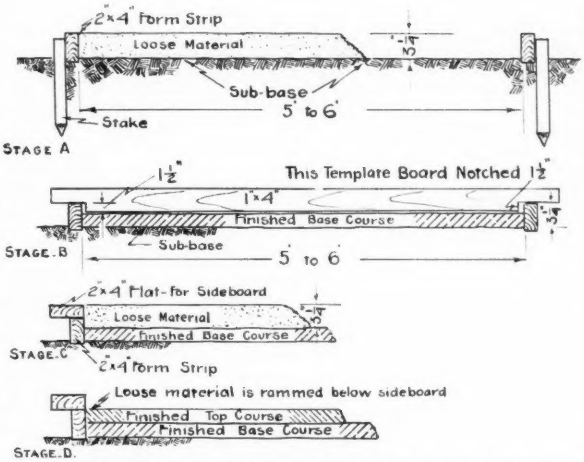


Fig. 2 The four stages shown here, including the exact dimensions shown, were used in building the soil-cement, oil-surfaced, and the raylig floors. Slight modifications of dimensions only were used in building the two "black-top" floors. Stage A shows the finished subbase with the loose soil mixture in the forms and ready to pack for the base course. Stage B shows the finished base course after it is packed in place. The template is shown in place for checking the remaining 1½ in that should be left between the form strips. Stage C shows one edge of the form upon which side boards have been laid to hold the loose top course material. A 2 x 4 laid flat and nailed is used for the side boards. Stage D shows the top course after packing. The top course should ram down about even with the original form strips; then the floor is finished

The soil mixture for the top course was exactly the same as for the base course, except that a smoother, better surface was obtained when the coarse aggregate was screened out and sand only is used. To this mixture is added 10 per cent of portland cement by measure. Some additional moisture will always be needed after adding the cement, to bring it to a moist consistency that is correct for packing. When the top course was packed, the floor was finished except for curing the surface by keeping it moist for three days. After three years of service the soil-cement floors indicate that this type of floor will make a very satisfactory low-cost floor. The cement cost 75c per bag and the cost of materials was $2.26 for 100 sq ft.

Oil-Surfaced Floor. This floor was of the same thickness and built in exactly the same way as the soil-cement floor, except that the top course was stabilized with road oil instead of with portland cement. The cold oil was sprinkled on the surface of the loose soil mixture for the top course. A highly volatile, light road oil was used. It is distributed by one of the largest oil companies and is known as "cut-back asphalt cold mix". (This oil is a critical war material and cannot be secured during the war period, but can be obtained in barrel lots in normal times through the company's local filling stations.) As indicated, this oil can be used without heating in any reasonable summer temperature which makes the floor simple to build. After the base course was packed as for the soil-cement floor, the side boards were placed on the form and filled with the same loose soil mixture. The surface was struck off smooth and then it was ready for the oil. The oil was sprinkled from a 5-qt salvaged lubricating oil can by punching nail holes in the bottom; it was sprinkled from a plank to prevent disturbing the smooth surface. By moving the plank ahead approximately the same distance each time and by roughly measuring the oil in the can each time, it was easy for the operator to spread the oil at the proper rate. The optimum rate or amount of oil was found to be 1 gal to 12 or 14 sq ft — probably 1 to 12 is slightly better.

After the oil was sprinkled, the floor was carefully protected against any traffic of bird or animal for 24 to 36 hrs depending upon the weather. The oil was then dry with a tough rubbery surface. The top course was then packed the same as for soil-cement. It was packed with care the first time over to prevent tearing the rubbery surface more than necessary. A seal coat of the same oil was brushed on the surface of this floor six days later at the rate of 5 qt to 100 sq ft. A priming coat of the same oil was also brushed over the top of the lower course just before the top-course loose material was placed. This oil coat was practically the same as the seal coat, being 6 qt to 100 sq ft.

This floor looks like concrete after it has been in use for a while, as does soil-cement. It has a higher thermal efficiency also. A section cut from a floor that had been in service three years showed the material to be bone dry below the oiled surface. The oil penetration after the top course was packed averaged about ¾ in. This floor after three years of service was in excellent condition. The oil cost 13.9c per gal and when a rate of 1 gal to 12 sq ft was used the cost of the materials was $1.54 per 100 sq ft.

Raylig Floor. "Raylig" is a trade name for a lignin solution which is made from a by-product of paper pulp manufacture. This product is made on the west coast and has been used to some extent in roadbed stabilizing in that region. This floor had a thickness of 3 in and was built in two courses. The 1½-in base course was made in the same way as the two preceding floors. The top course was a 1½-in mat stabilized with the raylig solution. In the best section of this floor raylig was added to the mixing water in the ratio of 1¼ qt of raylig to 2½ qt of water for each 100 lb of soil and sand (1 part of silt and clay to 3 parts of sand). Starting with a dry aggregate this gave a moisture content favorable for ramming and the top course was then packed the same as for the soil-cement floor. Six days later the surface was given a seal coat of cut-back asphalt oil. This floor has stood for three years with only one suspicious spot showing in the surface. A later report on it will be more dependable. Raylig is not available except on the west coast and no definite cost figure can be given for the Midwest. A rough estimate of $1.61 per 100 sq ft was made for it.

Rammed Earth Floor. This floor was of plain rammed earth. It was 3 in thick and packed in two courses. The base course was the same as for soil-cement described above. The top course was exactly like the base course. No stabilizing material was used in the floor. It was rammed with the optimum moisture and the base course was sprinkled lightly with water before the top course was laid down. The floor was put in use immediately. This floor is in its second year of service and although the surface seems hard it has roughened badly. Some pits in the floor are more than ½ in deep and the floor is rated unsatisfactory. Although much better than a soft dirt floor for the poultry house, the labor is not justified. A stabilized top course of either oil or cement can be built with about the same amount of labor. The cost of the materials was nothing for this floor.

CONCLUSIONS

In most cases conclusions have been drawn along with the discussion for each type of floor. These conclusions are based upon four years of service or less for all floors and should not be considered final. The soil-cement floor and the oil-surfaced floor have been the two types generally selected by farmers as being easiest for them to build and with a satisfactory low cost. The time required for building these two floors by an inexperienced crew was found to be just about the same as for building a concrete floor by hand mixing.

A heavy demand for instructions for building these two floors made it desirable to publish Experiment Station Circular 42, entitled "New Hard-Surfaced Poultry House Floors", on the two floors earlier than intended, and it should be considered as a progress report. All floors under test have been scrubbed and disinfected once or twice each year.

The surface of neither of the black-top floors was as smooth as the oil-surfaced floors. The M.C.3 tar oil made a smoother surface than the S.C.4 asphalt oil.

If soft and untreated spots are left around the edges of the new floors rodents will find them. *(Continued on page 141)*

*For optimum moisture, see South Dakota Exp. Sta. Circ. 42.

The Fence Exposure Tests

By B. A. Jennings
MEMBER A.S.A.E.

IN 1936 the American Society for Testing Materials (A.S.T.M.) completed the display of wire samples to determine the rate of atmospheric corrosion and the loss of strength due to corrosion. In order to obtain results representing widespread areas, eleven sites were chosen as follows: Pittsburgh, Pa.; Bridgeport, Conn.; Sandy Hook, N.J.; State College, Pa.; Lafayette, Ind.; Ames, Iowa; Manhattan, Kan.; Ithaca, N. Y.; College Station, Tex., and Davis and Santa Cruz, Calif.

This is a cooperative project. The A.S.T.M. furnishes the necessary materials, does the various laboratory test work, and is responsible for the assembling of data. The several colleges of agriculture have furnished the college test yards, did the construction work, and make the inspections at their respective sites. Much of the credit for establishing the working relationship between the A.S.-T.M. and A.S.A.E. and the several colleges concerned should go to Professor Howard W. Riley, head of the agricultural engineering department at Cornell University.

Each test yard is 100 x 200 ft, securely fenced in and contains (1) 72 samples of woven wire farm fencing, (2) 23 samples of barbed wire, (3) 21 samples of chain link fence, (4) 13 samples of stranded cable, and (5) seven duplicate sets of 120 samples for a total of 840 unfabricated wires mounted in frames.

These seven sets of unfabricated wires are to be removed at different intervals for determining the loss in weight of the covering and the loss of tensile strength due to corrosion. Another set went to the U. S. Bureau of Standards for complete analysis to determine the actual size, the chemical analysis of the coating and the base metal, the weight and uniformity of coating, and the tensile strength. Microphotographs were also taken to show the structure of the coating.

The unfabricated samples are from the same stock as that used in the manufacturing of the woven and barbed wire fencing. This affords an opportunity for laboratory test work without destroying the fence samples.

This paper will cover the following four points:

1 How atmospheric corrosion affects the different materials used in the fence tests.

2 The effect of rust or corrosion on the tensile strength of wire.

3 The variation in rate of corrosion at the several sites due to differences in atmospheric conditions.

4 How the weight of zinc coating affects the life of galvanized wire.

First, as to the effect of corrosion on the five different materials used in test fences and wires, the copper-covered wires tarnished or turned to a dark, greenish black color the first year and they have remained this way since then, without rusting.

Paper presented at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1943. A contribution of the Farm Structures Division.

B. A. JENNINGS is professor of agricultural engineering, Cornell University.

The corrosion-resistant steel wires have withstood six years of exposure and they are as yet in excellent condition. The nickle-chromium alloy wires are as bright or brighter than the day they were installed. The chromium alloy wires show some dark speckling and some of the samples have yellowed. The exposure period has not been long enough to determine the tendency of this type of fence.

The lead-coated wires showed the effect of corrosion the first year, with the appearance of numerous small blisters or rosettes of rust. Because of this "pin hole" rusting and the yellow stain on the surface, this type of wire might have been scored fairly high as to the percentage of rust on early inspections. In a number of cases on later inspections less rust was reported. There is a possibility that the pin holes seal up and the samples may actually show less rusting.

Zinc-coated galvanized wire in corroding passes through definite stages. After a period of time the bright metallic color of the zinc turns dark, usually in spots. Following this the wire takes on a yellow tinge which in turn is followed by actual rusting.

In the galvanizing process there is formed a layer of zinc-iron alloy between the zinc on the outside and the base metal. Weathering gradually removes the zinc, leaving the black color. When the alloy layer is exposed, the wire turns yellowish which is evidence of superficial rusting. Not long after this period actual rust will appear in the spots where the base metal is exposed.

An interesting side light on the corrosion of zinc-coated wire is the protection the zinc gives to bare spots. The exposed cut ends of the barbs and at the joints on woven wire remain bright and free from rust nearly as long as the rest of the fence.

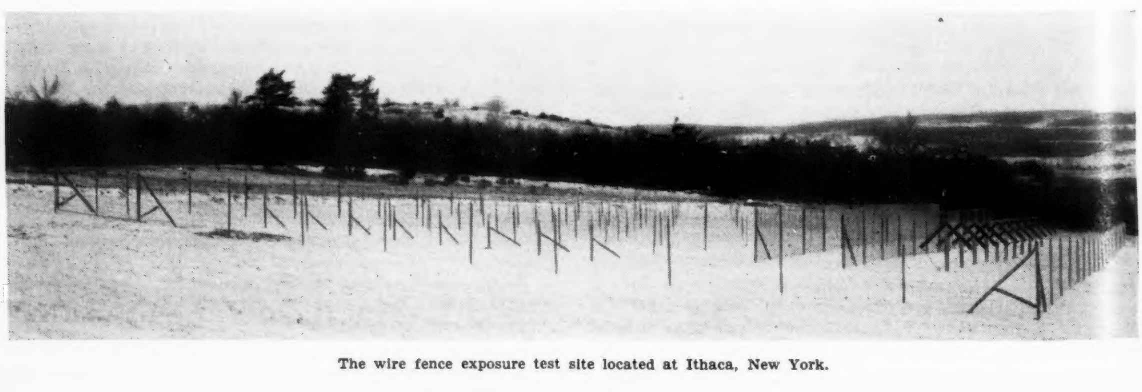
The uncoated or bare steel wire on exposure to the atmosphere started to rust immediately and in a very short period was 100 per cent rusted. The copper content had no bearing on when the steel started to rust.

As to the second topic above, namely, the effect of corrosion on the tensile strength of the wire — until corrosion begins there is no loss of strength; in fact, many of the wires showed a slight gain. This strength increase tendency has now substantially stopped. (The maximum was 4 per cent.)

The complete picture of the life of bare or uncoated wire for all of the sites is not known but the trends and information obtained at Pittsburgh are valuable. Copper-bearing bare wires from this site are continuing to corrode less rapidly than the low copper specimens. The difference is not significant at the other locations.

The life and the rate of loss of tensile strength vary with the size of wire. At Pittsburgh $14\frac{1}{2}$-gauge uncoated wire lost 86 per cent of its strength in 6 years, while 9-gauge wire lost only 31 per cent. This is to be expected. There is, however, evidence that the small gauge wires undergo more rapid penetration than do the larger wires.

One important result of work so far that should be noted is that the penetration of corrosion on zinc-coated wire (that is, zinc



The wire fence exposure test site located at Ithaca, New York.

coated after rust, compared to bare steel wire) after rust appears is very similar to that on bare uncoated wire.

With reference to the third point, namely, the comparison of the various sites as to corrosion of the samples, Pittsburgh with its atmosphere highly contaminated with sulphur fumes ranks first. Bridgeport, also in an industrial center, and Sandy Hook, because of its salty coast atmosphere, are nearly as bad. Lafayette, State College, Ithaca, Ames, and College Station, Tex., are similar, but the rate of corrosion is much slower than that at the first three. Manhattan, Davis, and Santa Cruz are quite similar and below those mentioned above.

A better idea of the marked variation in the rate of corrosion at the various stations after 6 years can be obtained by comparing wire with varying weights of zinc coating that has started to rust:

At Pittsburgh:	1.9 oz per sq ft is	100 per cent rust
At Sandy Hook and Bridgeport:	0.9 " " " " "	1 and 3 per cent rust
At State College and Lafayette:	0.5 " " " " "	1 per cent rust
At Ames, Ithaca, and College Station:	0.3 " " " " "	1 to 38 per cent rust
At Manhattan, Santa Cruz, and Davis:	0.25 " " " " "	no rust

In other words, a fence with a 0.25-oz coating at Manhattan, Santa Cruz, or Davis will last longer than one with a 1.9-oz coating at Pittsburgh.

One of the most important results obtained so far is that for any given exposure there is a fairly definite rate of loss of zinc. Knowing the rate of loss, one can determine the length of time required for 100 per cent rust for any given coating. From the information obtained from the bare uncoated wire as to loss of strength (similar to 100 per cent rust on zinc-coated wire), the expected life of any given fence can be predicted with a fair degree of accuracy. We now have sufficient information so that a manufacturer or a consumer desiring a fence of a certain length of life can write the specification without waiting 10 to 25 years for the test fences to rust out completely. As time goes on additional information will make the task easier and more certain.

All the work, time, effort, and dollars that have gone into this project will be of little value, however, unless it is used and used wisely. Manufacturers and large consumers who have facilities for writing and checking specifications will receive much value from this work. Our responsibility as agricultural engineers is to utilize this information for the good of agriculture.

The data presented in this paper is only a small part of that which is now available. Anyone interested in complete detailed information can obtain copies of the A.S.T.M. reports of Committee A5 on the Corrosion of Iron and Steel. The 1937, 1939, 1941, and 1943 reports are the most useful.

Floors for Poultry Houses

(Continued from page 139)

Especial care is necessary in finishing the edges in order to make them rodent proof.

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Combine Harvesting by Terrace Intervals

By John R. Carreker
MEMBER A.S.A.E.

TERRACE ridges constructed on typical southern Piedmont cropland fields of moderate to steep slopes are generally too abrupt and too high for tractor-drawn combine harvesters to cross them. It is therefore necessary to operate within terrace intervals when harvesting small grain, lespedeza seed, and other combine-harvested crops.

Combine operators generally make their first cut in a terrace interval as a complete round, adjacent to the terraces. The tractor and combine wheels necessarily crush down some unharvested crop, leaving wheel tracks. A small amount of trampling is, of course, unavoidable. Cutting then continues toward the midinterval, until the main terrace interval area has been cut, then a swing or two around the outside cuts to the terrace-ridge crests to complete the job.

With combines that put the straw out to the side of the machine, a goodly portion of the straw is left on the terrace ridge and in the terrace channel, with a wide space in the midinterval area without any straw covering. This is undesirable for three reasons. First, the straw on the terrace interferes with maintenance and proper functioning of the terrace. Second, turning land leaves a strip of poor land in the midinterval area at the deadfurrow. Straw removed from this area tends to deplete it further. Third, the straw is removed from the location at which it is most needed to resist erosion.

These difficulties were overcome by a process of cutting both wheat and Kobe lespedeza seed on the Southern Piedmont Experiment Station in 1943. The first cut was made near the center of the terrace interval parallel to the downhill-side terrace. The return trip was made with the tractor running in the first cut. Each succeeding cut was made working outward from the opening thus made.

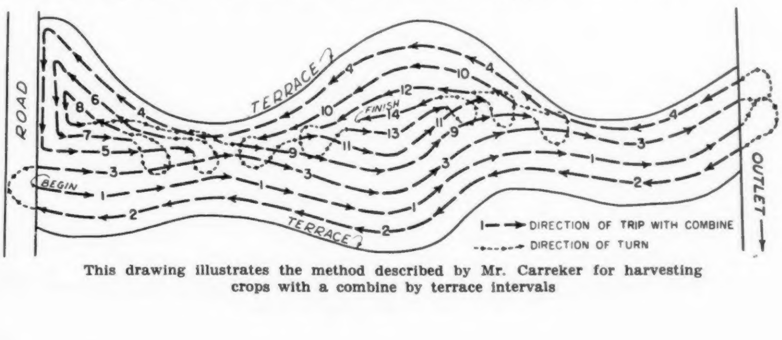
Islands in the wide places between terraces were left adjacent to the uphill-side terrace. When all through cuts were completed, the islands were finished from the outside, cutting toward the center. This entire procedure is shown in the accompanying illustration.

An exact time and yield record was kept comparing the method under discussion with the conventional method of harvesting wheat on a series of comparable adjacent terrace intervals of class III land. There were no discernible differences in either time of harvest or yield by the two methods. Likewise, detailed field observations while harvesting Kobe lespedeza seed indicated no differences in time or yield with the two methods.

A decided advantage, however, was gained by the new method over the old in that only a small amount of straw was deposited on the terraces and practically all the straw was placed in the midinterval area where it is most needed.

This article was prepared expressly for AGRICULTURAL ENGINEERING.

J. R. CARREKER is associate agricultural engineer, Southern Piedmont Experiment Station, Soil Conservation Service, U. S. Department of Agriculture.



This drawing illustrates the method described by Mr. Carreker for harvesting crops with a combine by terrace intervals

A Postwar Program for Irrigated Land Expansion

By John W. Haw

THE decision to proceed with any extensive program of utilizing our arid lands through construction of irrigation works in the postwar era must be based upon acceptance of the following premises: (1) that it is good economics, common sense and sound business to produce so far as possible our present and future food and fiber requirements in this country; (2) that the change-over from a war to a peacetime economy will test severely the brains and brawn and financial resources of this country, and that effecting such change-over without widespread dislocation of established business and chaotic unemployment and financial conditions is our number one problem and responsibility, rather than world rehabilitation; (3) that sound international relationships must be based upon a solvent, stable and satisfactory national economy in this country; and (4) that deficit spending must come to a stop somewhere; consequently public works programs to absorb unemployment and stimulate business should be, so far as possible, regenerative in character and self-liquidating as to capital expenditures.

However you may disagree in detail, agreement with these general principles is necessary if you are to endorse a program for reclaiming western arid lands by irrigation as economically desirable and a sound business investment in the postwar period.

Careful reconnaissance and engineering investigation, principally by the U. S. Bureau of Reclamation, has disclosed the existence of feasible projects which would add about 20 million irrigable acres to the farming area of the 17 western states. By feasible projects is meant those embracing land with good soil and suitable topography and for which an adequate irrigation water supply can be provided at a cost which can be repaid by the water users on the usual terms after just and equitable allowance for subsidiary benefits.

Out of the aggregate of such projects it can be safely assumed that 50 per cent are both highly desirable and upon which engineering data are now available or could be made available in a relatively short time. For the purposes of this paper I am therefore proposing a program for the construction of multipurpose reclamation projects with the irrigation of 10 million acres to be the predominant objective. Obviously this is a round figure chosen for purposes of discussion without regard to selection of specific projects. Such a figure would boil the potentially irrigable lands down to the projects with the best soils, those most favorably located climatically and which can be developed well within the known limits of repayment.

Time does not permit a full discussion of *all* the arguments which favor adoption of such a program. I shall attempt merely to advance ten good reasons for my belief that this country should start *now* to plan through to the detailed blueprint stage for such a reclamation program — work to begin with the cessation of hostilities.

1 The construction work under this program will promptly provide temporary employment in great volume in that section of the country in which postwar unemployment will be particularly acute. The mass migration of workers in recent years to war industries on the Pacific Coast is well known. Census estimates of population made on March 1, 1943, indicate an increase in civilian population in the Pacific Coast states between 1930 and 1943 of 27.7 per cent as compared with an increase for the entire country of 4.4 per cent. A part of this increase must be absorbed in some new form of employment as exclusive war material industries close down. Unless there is such provision these migrants will start flowing back into areas less able to integrate them into a peacetime economy. Under the suggested plan, as construction work is completed, workers will find permanent occupation on farms and in the cities and villages which will rise out of the desert.

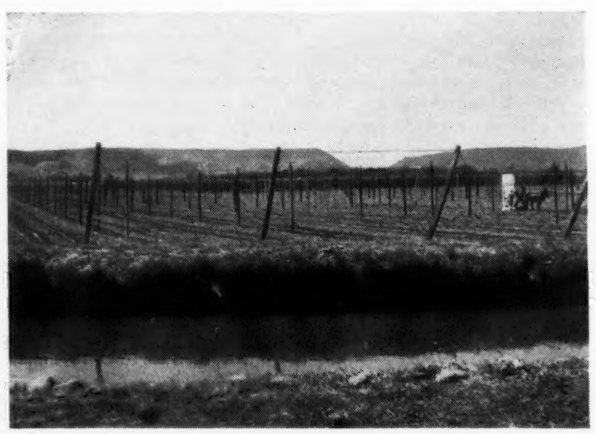
2 It will prevent or substantially alleviate two types of recurrent national disaster — floods and drought. Upstream storage provides run-off regulation downstream and irrigation projects are the best known device for providing stability on farms and ranches in an arid country, subject to wide fluctuations in rainfall.

3 It will create in areas now waste or sparsely populated, opportunities for 125,000 profitable farms and a means of livelihood for 250,000 business and professional men, tradesmen, mechanics, and craftsmen in the cities and villages which service these new rural areas. This rough calculation is based on 80-acre irrigated farms and the well-known fact that in an agricultural area twice as many people make their living in urban centers as are directly engaged in agriculture. These figures add up to the equivalent of two average agricultural states.

4 It will step up production of foods and fibers gradually over the long period of years required to bring irrigated land into full production and the products will be almost exclusively those which we have never produced in surplus. Thus consumptive needs of a population expanding in number and in requirements arising from higher standards of living can be supplied from domestic sources. Population growth in this country between 1930 and 1943 is estimated at about 13,000,000 and is increasing now at the rate of about 1.2 to 1.3 million yearly — and we must not lose sight of the fact that it requires approximately 3 to 3.5 acres of cultivated land per capita to produce the foods and fibers for which there is demand at present levels of consumption. Considered in the aggregate we were a net import nation on agricultural commodities before the war. Not only are there bound to be declines in soil productivity in many areas of the older settled states, but actually through erosion and seepage hundreds of thousands of acres are being retired from production yearly. Now that horse population is down to near the irreducible limit we can no longer count on the acres taken out of production of horse feed to meet the needs of increasing population. This has been the shock absorber for 25 years but is no longer available. With the restoration of normal conditions after the war, the number one national problem will be a means of increasing our agricultural plant. Increased production on favorably situated existing farms will not alone solve the problem. We will need two new farm states.

5 Irrigation projects with few exceptions have a good record of repayment of construction costs. They carry their own cost of maintenance. I have reason to know that the exceptions to that record boil down to wildcat promotional projects, projects in obviously poor locations or constructed on unsound plans. Good projects have demonstrated that they can repay the cost of their water right, if payments are adjusted to yearly net farm returns and the

(Continued on page 144)


Back of the irrigation canal in the foreground of this picture is a field of hops, on the Yakima (Wash.) federal reclamation project

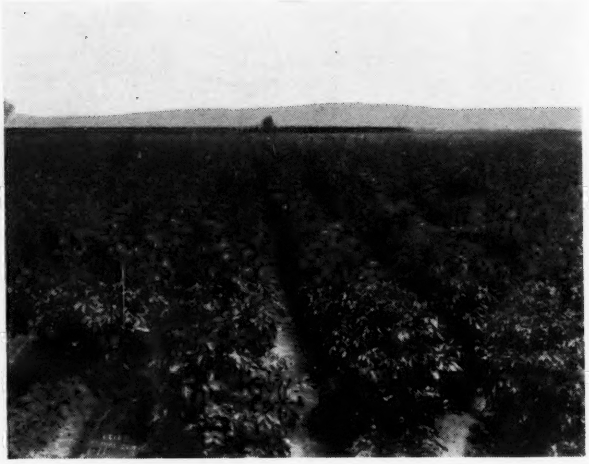
Paper presented at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1943. A contribution of the Soil and Water Division.

JOHN W. HAW is director, department of agricultural development, Northern Pacific Rwy. Co.

(Continued from page 142)

repayment extended over a long period.

6 It will produce yearly about one-half billion dollars of new wealth. This new wealth injected into the financial bloodstream of the nation, derived from now unused soil, water, and air, is a primary infusion. It sets in motion forces which result finally in additions to national income estimated at five times the amount of the new wealth originally created. Many calculations have been made as to the turnover in the channels of our trade and commerce, of dollars derived in the first instance from our mineral, forest, soil, and sea resources. It is commonly accepted that effect of such dollars is multiplied from three to seven times in national income.



A field of potatoes under irrigation in the Yakima Valley of Washington

7 It will create vast property values and will generate company, corporation, and private incomes appreciably broadening the taxation base for the nation, the states, and their political subdivisions. This country faces a very real problem in seeking types of postwar public works potentially regenerative in character and which at the same time are in fields unattractive for private capital and enterprise. We will face in the postwar years the task of servicing and eventually liquidating a debt at least six times as large as existed during the public works program of the thirties. This situation poses entirely new, complex and momentous problems. Public moneys are derived from taxation and taxes have their source in private property and private and corporate incomes. When government expenditures take place in fields adapted to and attractive for private enterprise there are two results. First, a reduction in the earnings of private business and thus its inability to pay taxes and, second, the scope of enterprises which enjoy tax freedom is enlarged. Unfortunately the effect is cumulative. Tax freedom at present taxation rates creates an advantage absolutely impossible for private business to offset. Carried to its ultimate conclusion this process presages finally the complete retirement from the investment field of private initiative and private funds and the substitution therefor of government agencies. This is state socialism.

Construction of reclamation projects does not violate the principle of government expenditures in their proper field.

8 It will buttress the war-expanded industrial developments on the Pacific Coast with a nearby dependable food supply, large blocks of relatively cheap hydroelectric power and closeup consumer markets. These three factors are universally recognized as those required to entrench insecurely rooted industrial developments.

9 It will harness and put to work another unused and wasting national resource — falling water. Storage dams, at which the fall of the West's great rivers can be capitalized for power generation, are a necessary part of irrigation projects remaining for construction. This power channeled through industries can soundly exploit the mineral and timber resources of the western country and Alaska, providing added employment and priming the pump of national income with new wealth.

10 It will contribute to continental solidarity and substantially aid in the defense of this country for all time to come against enemies both within and without. Industrial development on the Pacific Coast and in the intermountain country and the creation of 10 million acres of new farm land with its complementary cities and villages necklaced along the streams and arteries of transportation will knit together the East with that vast country between the Pacific Coast and the Mississippi. The West has two-thirds of the land area of the country and but one-sixth of the population. It is now an undigested area breeding human problems and recurrent economic distress. It is unquestionably in the national interest to foster development of this area as a more self-sufficient, politically stable and defensible segment of the country.

In conclusion, it is my contention that this program harmonizes with the view of those who hold that a bold, dynamic program of production which will stimulate employment and create wealth is imperative if this nation is to maintain present high standards of living, retain our present form of government and eventually liquidate the huge war debt which will be a mortgage on the country's future.

Such a program would mean an initial outlay of from two to three billion dollars expended over a period of from 10 to 25 years. Just for comparison, the Navy is requesting an appropriation of five billion dollars — over twice the amount proposed for this program — merely to construct landing barges and escort vessels. The reclamation program is not an out-of-pocket charge but a bookkeeping item. It is an investment, not an expenditure. Where else can this nation buy two states — two new states which would agree to refund their purchase price in the next 50 years while at the same time contributing to a solution of our manifold postwar problems?

There may be other great postwar projects of national or regionwide scope but none has been so far proposed equally well tailored to speed the convalescence of the United States at the war's close.

Farm Work Simplification

(Continued from page 136)

of constantly increasing the efficiency of output of each worker and of each unit of equipment in agriculture.

There has been some tendency to overestimate the probable effect on agriculture of industrial markets. Some would have us believe that industrial uses of the raw materials of agriculture will usher in a new and greatly expanded era of prosperity. The tremendous advance in chemistry and chemical engineering resulting from the emergency of war has multiplied the successful uses of agricultural materials for industrial purposes. But the same advances in chemistry have made the chemical industries increasingly independent as to raw materials. If agricultural products are to compete with other basic materials for industrial outlets, it will probably be necessary to do so at prices lower than normal food and fiber prices. I do not wish to infer that process analysis and time study alone will make possible the production of large quantities of agricultural raw materials at prices to compete with other and cheaper raw materials. However, in so far as we wish to go in that direction, these techniques of analyzing and simplifying farm work will be useful.

One more point should be made relative to the need of increased productivity of agricultural workers. In the past, most farmers have had two elements of income — one from their farming operations; the other from real estate whether they realized it or not. The social and economic development of most land in the United States has been so recent that the appreciation of land values — perhaps it is better to say land prices — which accompanied that development is still felt as a powerful influence in our economic structure. It is rapidly becoming more memory than actual effect but still colors general thinking. Nevertheless from the beginning of the history of this country to the present time many farmers have been able to be indifferent farmers and yet retire with a modest fortune — an unearned increment of value attaching to their land.

It must be recognized that during this period of rising land prices the productive abilities of most agricultural land was permanently reduced by cropping and erosion. Even if the best of modern methods of conservation are used, these soils will not for a long time, if ever, yield as abundantly as they once did.

(Continued on page 154)

800 LBS. AT THE PUMP

You can't get the Super FMC Fire-Killing Fog without High Pressure (800 lbs.)

FMC HIGH-PRESSURE PUMP
THAT HAS REVOLUTIONIZED MODERN FIRE-FIGHTING TECHNIQUE

Fight your fires the modern way —*with fog. You must have* high pressure. At least 800 lbs. at the pump—600 lbs. at the gun!

The reason? To cool and smother flame effectively, you need a combination of *finely-atomized* fog and high velocity resulting from FMC 600 lb. gun pressure. Every droplet of water must be broken up into thousands of tiny particles and "blasted" into the source of the fire.

That's why there is only one FMC Fog Fire Fighter and why it is in a class by itself. The FMC High Pressure Pump provides *more than* 800 lbs. pump pressure (600 lbs. nozzle pressure) *easily* — without over-working.

800 LBS. AT THE PUMP! That's a pretty tough job for any unit. But—the FMC High-Pressure Pump has proved its ability to *deliver* and *maintain* that pressure at hundreds of fires.

It's got "what it takes" to do its job and to carry through.

Here's why! The FMC Pump is ten years beyond the experimental stage. It is sturdy, compact and trouble-free. All parts are bathed in oil. It runs at slow speed — and last — but not least — it is designed to deliver *more than* 800 lbs. pump pressure.

Investigate! There's nothing else like it!

BUILDERS OF BEAN HIGH-PRESSURE

A *MUST* FOR HIGH-PRESSURE FOG FIRE FIGHTING

FOG FIRE FIGHTER TRUCK. *A self-contained fire-fighting unit. Carries its own water supply and complete equipment. Designed for fighting all types of town, rural and airport fires.*

Fires put out 10 times faster with little or no water damage

FMC High-Pressure Fog extinguishes fires—fast!

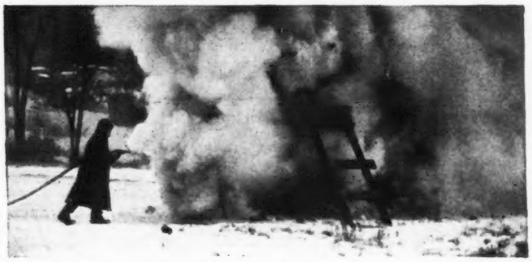
The finely-divided fog is "blasted" right to the fire, cools and smothers it. One gallon of this finely-atomized water properly used has the fire-quenching possibilities of 10 to 35 gallons of low pressure water.

The result? Faster quenching and practically no water damage!

Furthermore—the FMC Fire Fighter is a complete fire fighting unit. The 60 gallon pump capacity at 800 lbs. pump pressure (600 lbs. nozzle pressure) supplies two guns of 30 gallons each. The 600 lbs. nozzle pressure and the 30 gallons discharge capacity are so well balanced that it is a one-man gun.

Get the Facts on *Real* fog fire fighting from the John Bean Mfg. Co., Lansing, Mich., or the Bean-Cutler Division, Food Machinery Corporation, San Jose, California.

FOG AT WORK! *This test fire started in building filled with boxes and furniture. Fireman using straight fog stream to knock down hot fire quickly from a safe distance.*



FIRE'S OUT! *Fireman adjusts nozzle for wider fog pattern as he moves in closer. Within a few seconds, the fog has done its work on fire inside structure. Its effect can be seen from steam pouring out.*

Original **HIGH-PRESSURE FOG FIRE FIGHTER**

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PUMPS FOR OVER FIFTY YEARS

Lamps as Sources of Heat

By Lawrence C. Porter
FELLOW A.S.A.E.

THE selection of the proper lamp for any specific heating purpose without knowledge of the physics of radiation is difficult. It is complicated because there are lamps that emit infrared energy at various wave lengths yet appear alike externally. While all infrared is heat, the wave length determines the relative efficiency with which various heating jobs may be accomplished. For example, infrared lamps designed for paint and enamel drying operate at 2500 deg K because that temperature emits infrared waves of a length which penetrate such materials most readily. On the other hand, the shorter infrared waves penetrate flesh more readily. Theoretically, the most effective therapeutic lamp generates infrared of wave lengths very close to those of visible light, but their use is limited by their glare. Lower temperature sources, even though they do not penetrate quite so deeply, are more comfortable to use.

All incandescent lamps are better sources of infrared than of visible light. As a matter of fact, about 90 per cent of the energy put into a lamp is emitted as infrared, or heat, and only about 10 per cent as light.

If a large boulder is rolled into a pond of still water it will cause a big splash and set up several large waves, separated by perhaps several feet, that chase each other across the pond. These might be represented as at A in Fig. 1. If instead of the large boulder we throw into the pond a good-sized rock, similar waves are set up but they will be smaller and closer together, as represented at B. Now suppose we drop a little pebble into the water. Still smaller and less widely separated waves are set up, represented at C. All three of these illustrations are water waves, but of different wave length, that is, distance from the crest of one wave to the crest of the next, as indicated by D.

This is a very simple analogy to infrared radiation, which also consists of waves, but instead of travelling across the surface of water they travel through air. They, too, are of different wave length. The longer infrared waves are known as far infrared, the medium ones as middle infrared, and the shorter ones as near infrared. Actually their wave lengths instead of being measured in feet or inches as with water waves are a very small fraction of an inch, starting from approximately 0.00003 in for near infrared, 0.00005 in for middle infrared, and 0.0001 in for far infrared which is used for ordinary heating, although the so-called far infrared waves actually extend to 1,000,000 Angstrom units or more and become electric waves used for heating by means of high frequency or diathermy, and above that radio waves used for communication and broadcasting.

As a matter of convenience, such very short waves are measured not in inches but in what are known as "Angstrom units" (variously abbreviated A, A°, AU, or λ). One A equals 0.000000004, or 1/250,000,000 in. The near infrared waves center at approximately 10,750 A, the middle at 19,500 A, and the far infrared at 37,000 A.

Incandescent sources emitting any of the above wave lengths also emit both longer and shorter waves than the central ones. At just what wave lengths the infrared passes from near to middle to far is not a definite figure. In general, however, near infrared may be considered to cover the range from 7500 to 14,000 A, middle infrared from 14,000 to 25,000 A, and the far infrared from 25,000 to 50,000 A.

As a matter of general interest the infrared waves form a very small portion of the entire electromagnetic spectrum. This entire spectrum contains waves of infinitely short lengths to waves that are a mile or more in length. The relative position of the infrared waves in the spectrum is shown by the following arrangement: Cosmic waves (extremely short), Gamma waves, X-ray waves, ultraviolet waves, visible light waves, infrared waves, and radio waves (very long).

Without going into the physics of the generation of infrared radiation by artificial sources, it is sufficient to say that the passage of electricity through a conductor such as the filament of an incandescent lamp generates infrared radiation over a wide range of wave lengths from the near to the far infrared. For the purpose of study — measurements of the relative amounts of energy of different wave lengths and experimental work on the effects of various wave lengths — they can be separated by passing them through a prism. We all know that a glass prism placed in a beam of sunlight will break up the beam into the different colors of the spectrum. The various colors are produced simply by a difference in wave length. Similarly, what differentiates near, middle and far infrared is wave length. A prism separates the various infrared waves as well as the various waves of visible light.

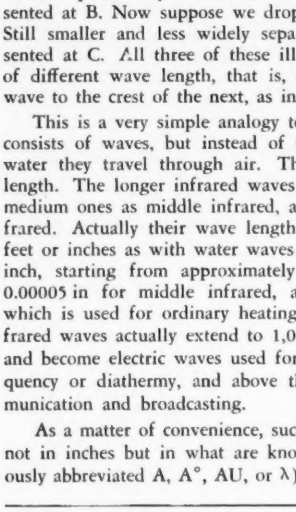
The wave length of the infrared generated is largely a function of the temperature of the source. With the tungsten filament lamp it is easy to obtain almost any desired peak of infrared energy by simply varying the voltage applied to the lamp. The interrelations of voltage, filament temperature, and peak infrared wave lengths emitted are shown in the following table, for a 250-w gas-filled Mazda C lamp:

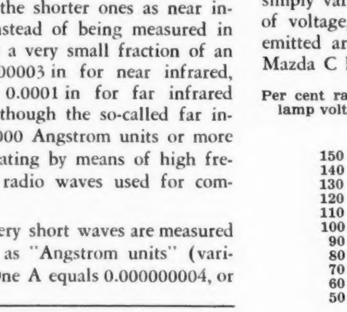
Per cent rated lamp volts	Per cent watts	Filament temperature deg K	Average filament brightness cp/cm²	Peak infrared wave length, A
150	190	3330	2200	8500
140	169	3240	1800	8800
130	152	3150	1425	9100
120	133	3055	1140	9400
110	117	2955	830	9800
100	100	2850	640	10200
90	83	2745	460	10600
80	70	2630	310	11000
70	58	2510	200	11500
60	45	2375	120	12000
50	32	2230	55	12250

(Continued on page 156)

Paper presented at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1943. A contribution of the Rural Electric Division.

L. C. PORTER is illuminating engineer, Nela Park Engineering Division, General Electric Co.





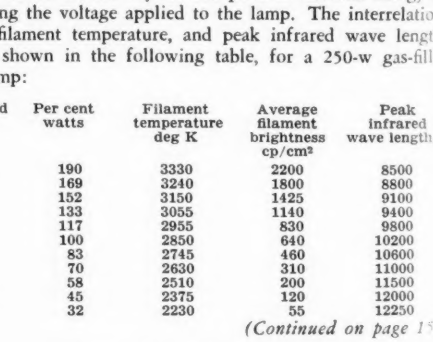
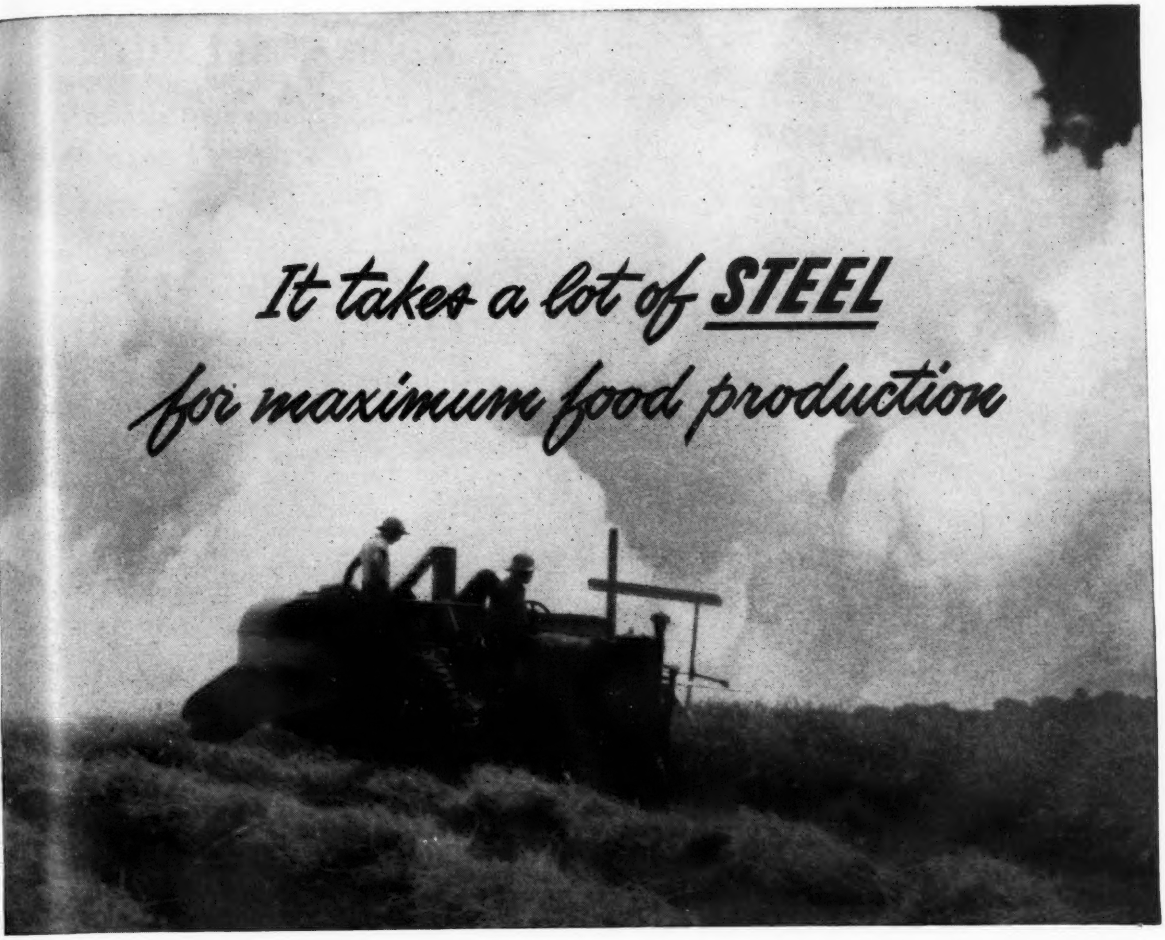


Fig. 1 (Left) The wave length indicated by D, determines the characteristics of radiations • Fig. 2 (Center) The curves show black body radiation, 1200 to 3400 deg K at equal total radiation • Fig. 3 (Right) Radiant energy distribution in a plane perpendicular to the axis of the lamp, 3 ft from the end of the bulb


It takes a lot of STEEL
for maximum food production

NEWS SECTION

A.S.A.E. Meetings Calendar

June 19 to 21 — Annual Meeting, Hotel Schroeder, Milwaukee, Wis.

December 11 to 13 — Fall Meeting, Stevens Hotel, Chicago.

A.S.A.E. Officers for 1944-45

AS A result of the annual election of officers of the American Society of Agricultural Engineers conducted by letter ballot, the following officers have been elected and will take office at the close of the annual meeting of the Society in June:

President, R. H. Driftmier, head, agricultural engineering department, University of Georgia.

Councilors (3-year term each), F. E. Price, research agricultural engineer, Oregon State College, and D. A. Milligan, director of research, Harry Ferguson, Inc.

The new Council of the Society for the year 1944-45 will include the above-named officers, together with the following: H. B. Walker and A. W. Turner, past-presidents; and E. C. Easter, B. P. Hess, W. D. Ellison, and F. C. Fenton, councilors.

The newly elected Nominating Committee of the Society consists of H. J. Barre (chairman), J. P. Fairbank, and C. N. Hinkle.

Pacific Coast Section Elects New Officers

AT THE annual meeting of the Pacific Coast Section of the American Society of Agricultural Engineers held at Berkeley, Calif., February 17, the following officers were elected for the ensuing year:

Chairman, Oscar W. Sjogren, agricultural engineer, Killefer Mfg. Corp.; first vice-chairman, R. A. Work, associate irrigation engineer, U. S. Soil Conservation Service; second vice-chairman, T. A. Bither, chief field engineer, California Corrugated Culvert Co.; third vice-chairman, H. C. Schwalen, professor of agricultural engineering, University of Arizona; and secretary-treasurer, Walter W. Weir, drainage engineer, division of soils, University of California. E. A. Olson, residential and farm sales manager, Idaho Power Co., was elected a member of the Executive Committee of the Section. The Section Nominating Committee for 1944-45 consists of: B. D. Moses (chairman), L. N. Brown, and Ben L. Hagglund.

The entire program for the meeting followed the symposium idea and no formal papers were presented. There was a total attendance at all sessions of 125 people, largely A.S.A.E. members.

Southwest Section's New Officers

THE Southwest Section of the American Society of Agricultural Engineers meeting at Dallas, Texas, March 10 and 11, elected the following officers for the ensuing year: Chairman, E. B. Doran, head, agricultural engineering department, Louisiana State University; vice-chairman, Roy E. Hayman, in charge of rural electrification, Oklahoma Gas & Electric Co., and secretary-treasurer, Kyle Engler, head, agricultural engineering department, University of Arkansas.

The Section rolled up a record attendance of 103 persons registered, and at the informal dinner sponsored by the Section 75 persons were present.

British Ag Engineers Feature Farm Mechanization

THE Institution of British Agricultural Engineers, according to information received from an A.S.A.E. member in England—Alexander Hay, assistant agricultural liaison officer, British Broadcasting Corporation — has been holding a series of four meetings in London dealing with the general theme, "Mechanization in Farming." The speaker at the first meeting last November was S. S. McKay, managing director of the Sunshine Harvester Co. At the second meeting in January, Prof. D. B. Johnstone - Wallace, deputy director of the National Institute of Agricultural Engineering, discussed mechanization of the family farm, and at the February meeting Clyde Higgs, chairman of the machinery committee of the National Farmers' Union, discussed mechanization as applied to the mixed farm. The concluding meeting in March featured F. A. Secrett, who discussed mechanization in market gardening. Lt.-Col. Philip Johnson, chairman of the I.B.A.E. acted as chairman of this meeting. The meetings were held at the Royal Society of Art.

(Continued on page 152)

Refrigerating Engineers to Meet in June

THE annual spring meeting of the American Society of Refrigerating Engineers will be held at the William Penn Hotel in Pittsburgh, Pa., June 5 to 7. Emphasis at the technical sessions scheduled for the forenoon and afternoon of the first day and the forenoons of the second and third days will be on current developments in the design and application of refrigeration equipment. The speakers are well-qualified authorities who will present papers on such subjects as frost zone psychrometry, hydrocarbon refrigerants, cold cathode lighting for refrigerated spaces, and effect of unstable heat flow on rapid temperature changes in confined spaces, refrigeration in synthetic ammonia production, and other subjects of equal timeliness.

Personals of A.S.A.E. Members

Frank J. Zink has opened offices in the Board of Trade Building, Chicago, where his services will be available as a "consulting agricultural engineer and farm market analyst." (See his card in the Professional Directory.)

For the past three years Mr. Zink has held the position of research agricultural engineer of the Farm Equipment Institute, prior to which he was associated with the tractor division of Allis-Chalmers Mfg. Co., as research engineer, in which position he was concerned largely with technical and economic analysis of agriculture in relation to types and sizes of power units and machines for which potential markets exist. Still earlier Mr. Zink was on the agricultural-engineering staff of Kanasas State College. He served in 1935-36 as chairman of the Society's Power and Machinery Division, and is currently chairman of its Meetings Committee.

Wendell L. Clark recently resigned as a junior agricultural engineer of the U. S. Soil Conservation Service to accept employment as junior project engineer with Harry Ferguson, Inc.

A. W. Clyde, professor of agricultural engineering, Pennsylvania State College, has a series of six articles currently appearing in "Farm Implement News" under the title "Mechanics of Farm Machinery." The series will be available later in booklet form.

E. D. Gordon is now employed in the experimental department of the John Deere Wagon Works at Moline, Ill., having resigned as associate agricultural engineer of the USDA Bureau of Plant Industry, Soils and Agricultural Engineering. He brings to his new work a fine research experience of thirteen years in the states of Georgia, Louisiana, and Alabama.

M. Glen Kirkpatrick has resigned after a service of 23 years on the editorial staff of "Farm Journal," having held the position of managing editor in recent years, to become associated with Dr. Hess & Clark, Inc., as director of Dr. Hess Service Bureau.

M. R. Lewis has resigned as senior agricultural engineer of the U. S. Soil Conservation Service to accept a position with the Department of Public Works of Venezuela as consulting irrigation engineer.

Walter H. Lloyd, formerly editor and manager of the "Ohio Farmer," and more recently in charge of the transportation and storage division, Office of Materials and Facilities, War Food Administration, has become associated with the Kraft Cheese Company at Chicago, to engage in producer relations activities, including the editing of the producer's edition of "The Kraftsman."

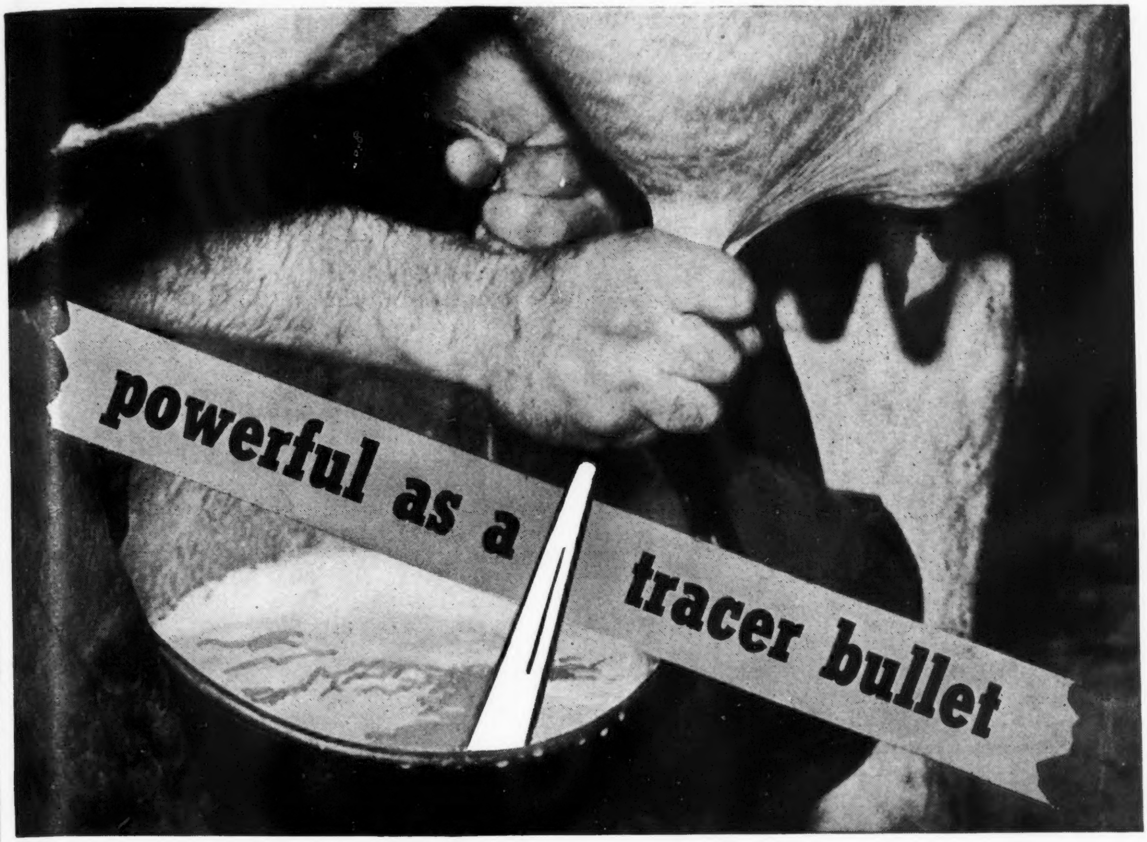
M. A. Sharp, head, agricultural engineering department, University of Tennessee, is author of Circular No. 87 of that institution, entitled "The Tennessee Liquid Fertilizer Distributor," which describes the development, construction, and application of the positive displacement pump developed by two agricultural engineers, H. A. Arnold and G. M. Petersen.

Donald K. Struthers has resigned as extension assistant professor of agricultural engineering, Iowa State College, to become technical representative of the Iowa Tractor & Implement Co., at Des Moines.

Odin Thomas recently resigned as personnel director of Harry Ferguson, Inc., to become director of Council for Market Development, an organization to handle problems in market analysis and in the selection and training of sales personnel.

Ben G. Van Zee was recently advanced to the position of chief engineer, automotive division, Minneapolis-Moline Power Implement Co., succeeding A. W. Lavers.

(Continued on page 154)



THE promise of milk and food for the starving children of the occupied countries is a most powerful weapon—as effective as tracer bullets.

Consequently our dairy, poultry, and hog farmers are forming the THIRD front, and taking as important a part in the war as though they carried a gun. Hundreds of thousands of them are adding 10 to 20% to their output through the use of Jamesway Equipment and Housing. Much of this increase is going into War Bonds. But still MORE FOOD IS NEEDED and MORE BONDS MUST BE BOUGHT.

Save Time and Effort

For more than 35 years Jamesway has helped up to 50,000 farmers each year to greater, more economical production on the farm with less effort.

See Your Jamesway Dealer

More and more Jamesway poultry, hog, and dairy equipment is available at the Jamesway dealer today. And the Jamesway man is always ready to help your farmers plan for the more efficient, economical and labor-saving production they will need after the war. For special folders on barns, poultry, or hog equipment write

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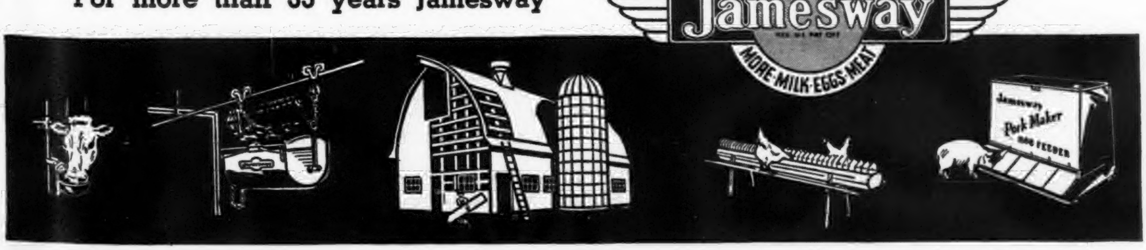

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

K. W. Anderson, research engineer, Deere & Co., Moline, Ill.

Franz E. Blackert, associate engineer, Soil Conservation Service, USDA (Mail) P. O. Box 1898, Fort Worth, Tex.

Hugh E. Curtis, managing editor, Successful Farming, Des Moines 3, Iowa.

Q. C. Delsman, president, Smalley Mfg. Company, 509 York St., Manitowoc, Wis.

Harry E. Gerrish, president, Morgan-Gerrish Co., 307 Essex Bldg., Minneapolis 2, Minn.

Roy S. Hendrix, rural engineer, Knoxville Electric Power and Water Board, Knoxville, Tenn. (Mail) 211 Fern St.

John F. McComb, director of sales, Stran-Steel Division, Great Lakes Steel Corp., 1130 Penobscot Bldg., Detroit, Mich.

F. W. Moffett, Jr., owner, Idylebrook Farms, 2234 Chili Road, Rochester, N. Y.

L. E. Sample, supply officer of coast artillery searchlight battalion, USA. (Mail) 351st CA SL Bn., APO 464, New York, N.Y.

F. R. Shultz, branch manager, J. I. Case Company, 310 N. Austin St., Dallas 2, Tex.

John F. Welch, assistant to the training and education supervisor, International Harvester Company. (Mail) 4221 S. Harrison St., Ft. Wayne 6, Ind.

John K. Windell, Jr., Co. M 389th Inf. Reg., USA, APO 98, Camp Rucker, Ala.

TRANSFER OF GRADE

Earl L. Arnold, War Production Board. (Mail) Apt D 431, 3004 N. Lee Highway, Arlington, Va. (Junior Member to Member)

George W. Crowther, assistant professor of agricultural engineering, University of Maine, Orono, Maine. (Junior Member to Member)

W. D. Scoates, 2nd Lt., USAAF. (Mail) College Station, Tex. (Junior Member to Member)

Donald K. Struthers, technical representative, Iowa Tractor and Implement Co., 1300 Walnut St., Des Moines 9, Ia. (Junior Member to Member)

Farm Work Simplification

(Continued from page 144)

How far can analysis of farming operations be extended? Probably there is no end to analysis and reorganization for greater productivity on farms any more than there appears to be an end to this process in industry.

Operations associated with farm machines are relatively advanced. They developed with the machine as a necessary element in designing the machine, and incidental to its subsequent use. Relatively speaking, chores and hand operations on the farm and usual farm storage methods are less well "engineered" than, for example, mechanical cultivation of corn. However, even with our most advanced machines we should not rest. They deserve, and will repay, close and careful examination by the techniques of process analysis and motion study.

How far should operation analysis and process reorganization be extended? On the larger commercial farms with competent management we may expect developments to approximate those in industry; otherwise agriculture will decline into relatively greater and greater disparity. On small diversified farms, which have many factors and reasons for being other than production of crops for sale, productivity is no less important. It is only through analysis of what is done followed by planned reorganization that improvement can be made, except by the very slow accumulation of knowledge in folkways which grow out of the expensive method of trial-and-error.

Farm management specialists and agricultural engineers are already working together profitably on a number of studies of farm work simplification. I cannot urge too strongly that we continue this joint effort and that an ever-increasing number of projects be undertaken using this technique.

Lamps as Sources of Heat

(Continued from page 148)

The relative distribution of infrared energy in the various wave lengths is illustrated by the curves of black body radiation, as shown in Fig. 2.

Applied to the various standard infrared lamps and other sources now in use for various heating purposes on the farm, we have the following data:

Source	Life	Temperature, deg K	Average brightness cp/cm²
Sun		6000	155,000
500-w R-40 photoflood lamp (No. R2)	6 hrs	3400	2560
250-w Mazda CX lamp	500 "	2950	60*
150 and 300-w R-40 reflector spot and flood	1000 "	2850	640
100-w A-21 drying lamp	Long	2500	190
250-w R-40 drying lamp	Long	2500	190
260-w G-25 carbon lamp	200 "	2200	95
250-w R-40 heat lamp	Very long	2000	16
Cherry-red nichrome wire	Indefinite	1200	0.01
Non-luminous calrod water heater		700	

*Inside frosted bulb.

The radiant energy distribution from these lamps is shown in Fig. 3.

It seems desirable at this point to discuss the practical uses of lamps as sources of heat and to point out the differences between the various infrared lamps now on the market. There are nine types of reflector bulb (R-40) lamps that unlighted look very much alike.

Lamp wattages vary from 150 to 500, but all have the same bulb and base. The primary difference in these lamps is that they are designed to burn at different filament temperatures. That results in the emission of different amounts of light at different brightnesses and different lengths of life. There are also two ultraviolet lamps in R-40 bulbs, known as the RS-4 and the RS sunlamps. The latter is sometimes preferred on account of the heat that accompanies the ultraviolet.

The 500-w photoflood lamp, for example, has a very short life, approximately 6 hr, but it emits a tremendous flood of light for photographic purposes, hence its name "reflector-bulb photoflood lamp".

The 300-w R-40 reflector spot and flood lamps operate at a lower filament temperature, have a life of approximately 1000 hr, and project a relatively narrow beam of light for spotlight work, or a wider beam for floodlighting.

There is also a 150-w R-40 flood and a 150-w R-40 spot lamp which operate at approximately the same filament temperature and brightness, but have a lower lumen output than the corresponding 300-w lamps.

The 250-w R-40 drying lamp operates at a still lower temperature with a correspondingly long life, something over 5000 hr, and is used for drying paints, lacquers, etc.

The lamp having the lowest filament temperature of all, with an indefinitely long life, is the R-40 heat lamp. It is designed at so low a temperature in order to keep its brightness at such a point that it can be used for therapeutic purposes with a minimum annoyance from glare.

Perhaps a brief review of some of the present uses for heat lamps on the farm may suggest some new or related applications.

Due to scarcity of metals the reflector bulb lamps, using but 1/10,000 the amount of aluminum previously required for a separate reflector, have come into wide use during the war for baby chick brooders, hotbed heating, food dehydrators, and supplemental heating in the home. They have saved the lives of thousands of baby pigs and lambs. In fact, university tests indicate that the use of lamp-heated baby pig brooders results in about 30 per cent more pigs reaching maturity. It has been found that the use of reflector flood lamps over tomato seedlings increased the poundage of ripe tomatoes by approximately 72 per cent, and that the fruit was ready for market 3 to 5 weeks ahead of unlighted crops.

The tanks of one armored division need about 25,000 gallons of high-octane gasoline In traveling a hundred miles.

A tank's tank is always thirsty

▶ Multiply the appetite of just one tank by thousands and it's easy to see why gasoline is "tight" in the United States. Also why there's less Ethyl antiknock fluid available in spite of stepped-up production.

More and more Ethyl is going overseas—for every gallon of America's fighting gasoline contains Ethyl fluid.

When peace comes again, it is certain much of this high-octane gasoline will be available for civilian automobiles, airplanes, trucks, buses and farm tractors. Even before the war, laboratory experiments with engines designed to utilize better gasoline indicated that we have by no means reached the ultimate in sound performance and economy.

Therefore, our research workers in Detroit and San Bernardino, who are now engrossed in war work, look forward to working with the engineers of the automotive, aviation, tractor, petroleum and other allied industries in making practical application of higher-quality post-war gascline.

* * *

ETHYL CORPORATION

Manufacturer of Ethyl fluid, used by oil companies to improve the antiknock quality of aviation and motor gasoline

CHRYSLER BUILDING, NEW YORK CITY

PROFESSIONAL DIRECTORY

Consulting Engineering Work In Farm Structures Field
Also Sales Engineering for Selected Manufacturers

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Member A.S.A.E. Associated with Howard S. Sterner Company, Consulting Structural Engineers, 30 East Broad Street, Columbus, Ohio

Consulting Agricultural Engineer & Farm Market Analyst

FRANK J. ZINK, A. E.

Member A.S.A.E. Suite 4300, Board of Trade Bldg.,
Telephone: Wabash 1558 141 W. Jackson Blvd., Chicago 4, Ill.

RATES: Announcements under the heading "Professional Directory" in AGRICULTURAL ENGINEERING will be inserted at the flat rate of $1.00 per line per issue; 50 cents per line to A.S.A.E. members. Minimum charge, four-line basis. Uniform style setup. Copy must be received by first of month of publication.

BUY WAR BONDS

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS OPEN

AGRICULTURAL MACHINERY SALES REPRESENTATIVES wanted, by well known track-type tractor company. Agricultural implement selling experience or farm background essential. Must have proven record of selecting and developing new dealers, handling collections, arranging bank facilities, demonstrations, farm and dealers' meetings, etc. Earning power limited only by ability of representative to develop sales potentiality of his territory. PO-159

AGRICULTURAL ENGINEER is wanted by a nationally known building material manufacturer to assist in farm building design and research and for product promotion and educational work in farm field. An outstanding opportunity for a man with ambition, initiative and ideas to establish a sound and attractive future for himself with an excellent firm. Position requires considerable travelling. Write fully in first letter stating salary requirements. PO-158

AGRICULTURAL ENGINEER with irrigation engineering experience in Italy or with experience under comparable conditions in the southern part of United States is wanted by a federal government agency. Applications should not be in draft classification in which they are likely to be called. A highly competent man able to advise local government authorities concerning the relative urgency of various engineering projects is wanted. He will probably have to work with local engineers and depend upon his own judgment. Write giving full particulars in first letter. PO-157

AGRICULTURAL ENGINEER wanted. The National Safety Council is seeking a qualified agricultural engineer for the staff of its Farm Division. The duties will be to promote and carry out programs in farm and farm home safety. If interested, write National Safety Council, 20 North Wacker Drive, Chicago 6, Ill.

EXTENSION AGRICULTURAL ENGINEERS. There are two vacancies on the agricultural engineering extension staff of one of the leading state colleges of the Middle West. Extension projects are conducted in farm equipment, farm structures, soil and water conservation, and rural electrification, but it is desired to have one staff member specialize in farm equipment and the other in drainage. Salaries will depend upon experience. Applicants should submit complete personal records. PO-156

(Continued on page 160)

The FARM MACHINE OF TOMORROW.. *Today*

FOX

The FOX PICK-UP CUTTER will mow, chop and load, in one operation, over 200 tons of grass silage a day.

—It will cut Corn of any height, chop it into silage and load it into wagons, all in one operation.

—One man, with the FOX, can pick up, chop and load, ready for the mow or stack, 2 tons of dry hay in 12 min.

THE owner of a FOX PICK-UP CUTTER is the fortunate possessor of "The Farm Machine of Tomorrow," not in the blueprint or experimental stage, but a machine with the kinks worked out and refinements perfected. The FOX solves the man-power problem in Haying and Silage Harvesting. With its Pick-up, Mower Bar and Corn Harvesting units, it is truly "The Farm Machine of Tomorrow . . Today."

Backed by 50 years of cutter building experience, the name FOX has always stood for expert workmanship and fine performance, as evidenced by the many enthusiastic testimonials from FOX Owners.

> The FOX Pick-up Cutter will mow, chop and load, in one operation, over 200 tons of grass silage a day.
> —it will cut corn of any height, chop it into silage, load it into wagons ready for the silo, all in one operation.
> —one man, with the FOX, can pick up, chop and load ready for the mow or stack, 2 tons of dry hay in 12 minutes.

We are building as many FOX Pick-up Hay and Silage Harvesters as the government will permit, but the demand is such that we are at the present time completely sold out for 1944.

R. C. Krueger

Secretary

FOX RIVER TRACTOR COMPANY

Pioneers of Modern Forage Harvesting

1844 NORTH RANKIN STREET

APPLETON FOX WISCONSIN

BACK THE ATTACK
BUY WAR BONDS

EMPLOYMENT BULLETIN

(Continued from page 158)

REGIONAL SERVICE MANAGER seeking postwar security is wanted by well-known, fast-growing manufacturer of farm tractors and implements who is expanding his organization to prepare for postwar opportunity. Man needed to contact distributors to see that factory service policies are inaugurated and followed through. Must be able to command respect; must know farm implements, their use, care and maintenance and be able to pass his knowledge on to others through meetings, training and supervision. Probably college trained with practical experience; married, and between the ages of 30 and 45. Salary open. Write in confidence to Director, Council for Market Development, 1404 Maccabees Bldg., Detroit, Mich.

FARM EQUIPMENT ENGINEERS. National merchandising organization planning large farm equipment program has openings for senior and junior design engineers. Write experience, draft status, salary expected. Replies confidential. PO-155

ENGINEER interested in drainage research wanted. Southern state with large acreage needing drainage plans to begin intensive research program. First letter should give training, experience and references. PO-153

RURAL ELECTRIFICATION SPECIALIST wanted by agricultural college for combination research and extension work. A very progressive southern state with outstanding rural electrification program. Salary commensurate with training, experience and ability. PO-152

AGRICULTURAL ENGINEERING opening in northeastern university. At present the activities will be largely in the extension service with some time devoted to development work in farm equipment and work simplification. Man with general interest or experience in agricultural engineering preferred. Full statement of training, experience, draft status and other information should be given in first letter. PO-150

AD COPY WRITER wanted. Man with some technical experience who is creative and has the knack of writing simple, forceful copy for industrial and technical advertising is desired. Permanent position and good opportunity for advancement with long-established 4-A advertising agency. Correspondence will be kept confidential. PO-146

ENGINEERS WANTED in our plants in CALIFORNIA, FLORIDA, ILLINOIS and other states. Must have had at least three years' experience in general machine design. Our work is postwar development of machines for use in agriculture and in fruit and vegetable canneries, packing houses, and processing plants. Please give full history, including family, also name of state in which you prefer working, and salary expected — also snapshot of yourself if available. Reply to Food Machinery Corp., San Jose, California.

POSITIONS WANTED

AGRICULTURAL ENGINEER with B. S. degree in agricultural engineering from a southern college, with experience in soil conservation; construction; fire-fighting equipment; farm buildings; equipment, and operation — and a farm owner, is available. A disabled second lieutenant of World War II, and has served as instructor in a U. S. Army motor school. Age 28 years; single; draft status, 4-F. Disability will not interfere with agricultural engineering work. Would like position that includes any part of agricultural engineering (preferably in southern states), but will consider any place if salary and living conditions are right. PW-360

AGRICULTURAL ENGINEER (B. S. in horticulture, B. S. in engineering and M. S. in agricultural education) with 25 years of experience in teaching, extension and research directly in the field of agricultural engineering, and at present extension agricultural engineer and department head, wishes a position where his training and experience will have an outlet in developing a full four-year curriculum, postwar rehabilitation courses, vocational-agriculture training courses, or opening new lines of approach in extension or research. Special ability in visual methods of presenting extension material and in the organization of cooperative extension programs. PW-359

AGRICULTURAL ENGINEER with B.S. and M.S. degrees in agricultural engineering and economics, with experience in resident teaching, extension, and research work at two eastern universities, 29 years of age, farm reared, in good health, and whose draft status is 3-D, would be interested in a position teaching agricultural engineering with an opportunity to do research work at some university, or would consider a position with a farm machinery or public utilities company. PW-358